tech engineering news

may 1954

Only STEEL can do so many jobs so well

They Chew Their Way to Wealth. These teeth are capable of chewing through earth, sand and rock for thousands of feet until they reach Nature's buried treasures of gas and oil. Rock bits like this need super-strength, amazing toughness, high resistance to impact, abrasion, and shock. So, many of them are made from USS Alloy Steels. And United States Steel also provides many other essentials for oil drilling, such as wire lines, drill pipe, cement, drilling rigs.

Scoop! And a big one, too . . . it can scoop out 21.5 cubic yards of earth per minute, has a boom 215 feet long! The drag lines, boom support cables and hoisting ropes on a behemoth like this must have great strength, durability, flexibility, fatigue resistance. Tiger Brand Wire Ropes, made by U.S. Steel, meet all requirements.

OPPORTUNITIES WITH U. S. STEEL

If you're thinking about what you're going to do after graduation . . . if you're interested in a challenging, rewarding position with a progressive company . . . then it will pay you to look into the opportunities with United States Steel. Your placement director can give you more details, or we'll be glad to send you the informative booklet, "Paths of Opportunity." United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

A Man Needs a Cookie once in a while! And when cookies are kept in a tight cookie tin like this, they'll be fresh and appetizing for him. The can is steel, of course . . . made out of the same USS Tin Plate that is produced by U.S. Steel to make millions of "tin" cans every year for the protection of food, oil, paint and countless other things.

For further information on any product mentioned in this advertisement, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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UNITED STATES STEEL

This trade-mark is your guide to quality steel

AMERICAN BRIDGE . . AMERICAN STEEL & WIRE and CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE
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UNITED STATES STEEL HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY

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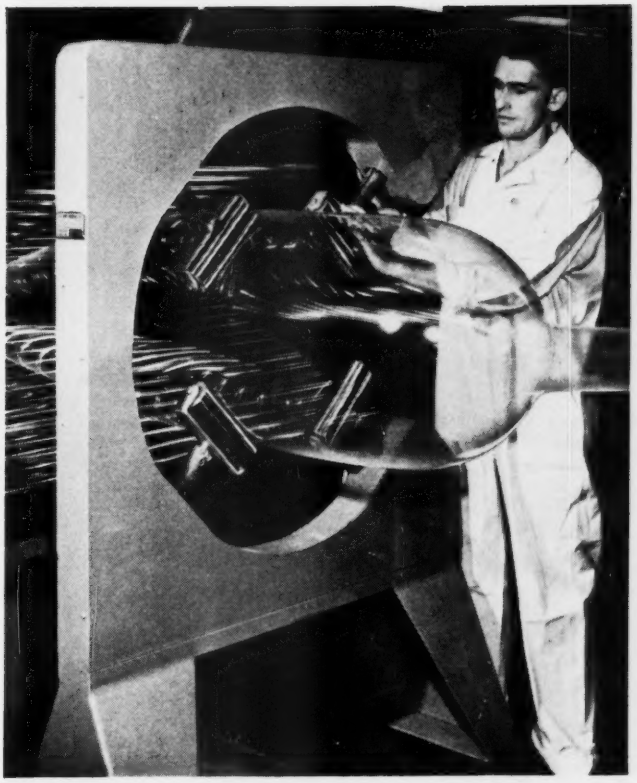

One of the early steps in the production of Saran-Wrap—the "bubble" that becomes a film after being deflated in a series of rollers.

Colorful display bins are an important part of consumer sales strategy and explain the advantages of Saran-Wrap.

TAKING CHEMICALS TO MANY MARKETS...

Dow succeeds through the careful coordination of group effort in research, marketing and sales

The high consumer acceptance gained by Saran-Wrap is a current example of what happens when extensive research and production planning is followed by coordinated marketing and sales strategy in launching a new product.

This amazing new plastic food wrap is certainly a useful product—but it is much more than that. For Dow it marks another milestone in a continuing effort to move into new fields of endeavor and to increase the variety as well as the size of its operation. Well-planned and executed projects, introducing varied industrial and consumer products, have been responsible for Dow's rapid growth to a position of prominence in the chemical industry.

Whether you choose research, production or sales, you can find a challenging career with Dow. Write to Dow's Technical Employment Department today for the booklet, "Opportunities with The Dow Chemical Company"—you'll find it interesting. THE DOW CHEMICAL COMPANY, *Midland, Michigan.*

you can depend on DOW CHEMICALS

DOW

Spring thoughts on the subject of...

rambunctious sheepskins

AN engineering senior can hardly be blamed for feeling rambunctious now that the years of hard study are nearly over and the sheepskin's in view.

But the sheepskin comes at Commencement. Commencement means you're set to start on your career. And that's certainly worth some serious thought.

To help you decide which job to pick, you'd do well to weigh the many reasons for choosing an engineering career at General Motors—reasons like these:

• At GM, an engineer has a real chance to follow his natural bent and work in the field of his choice. That's because GM produces a variety of products — automobiles, trucks, Diesel engines, refrigerators, bombsights, just to mention a few.

• At GM, you get the chance to work closely with top engineers, sharing their knowledge and experience. That's owing to GM's decentralization: 34 manufacturing divisions, 117 plants in 57 towns and cities. Yet each division draws upon GM's vast central research laboratories.

• At GM, there's a congenial climate for the personal and professional advancement of engineers. We respect the engineering point of view, as shown by the number of key GM executives in both divisional and top management who began their careers as engineering graduates on GM drafting boards.

Naturally, all this spells genuine opportunity for the young man who has what it takes. Your College Placement Office can arrange an interview for you with our college representative. Or you can write direct to us.

GM positions now available in these fields:

MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING
BUSINESS ADMINISTRATION

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

Compatible color television will eventually reach every TV home

The rainbow you can see in black and white!

RCA brings you compatible color TV. Lets you see color programs in black and white on the set you now own!

"When a modern and practical color television system for the home is here, RCA will have it . . ."

Echoing down through the years, these words—spoken in 1946 by David Sarnoff, Chairman of the Board of RCA—have a ring of triumph today.

Behind this great development are long years of scientific research, hard work and financial risk. RCA scientists were engaged in research basically related to *color* television as far back as the 1920's . . . even before *black-and-white* television service was introduced.

Since then RCA has spent over $25,000,000 to add the reality of color to black-and-white TV, including development of the tri-color tube.

The fruit of this great investment is the RCA all-electronic compatible color television system, *a system that provides for the telecasting of high-quality color pictures that can be received in full color on color receivers; and in black and white on the set you now own.*

RCA and NBC will invest an additional $15,000,000 during color TV's "Introductory Year"—1954—to establish this new service on a solid foundation.

RCA color sets are beginning to come off the production lines in small quantities. Although it will probably be another year before mass production is reached, the promise of compatible color television is being fulfilled.

RCA pioneered and developed compatible color television

INTRIGUING OPPORTUNITIES FOR GRADUATING ENGINEERS

You're sure to find the exact type of challenge *you* want in Engineering Development, Design, or Manufacturing at RCA. Men with Bachelor's, Master's or Doctor's degrees in EE, ME, IE or Physics are needed. *You'll find your optimum career work* among the hundreds of products RCA produces for the home, science, industry and Government.

If you have the necessary education and experience, you will be considered for a direct engineering assignment. Otherwise, you'll participate in our Specialized Training Program, in which you can explore RCA's many interesting engineering operations for a full year.

Your rapid professional advancement is enhanced at RCA by the free flow of engineering information.

Write today to: College Relations, RCA Victor, Camden, New Jersey. Or, see your Placement Director.

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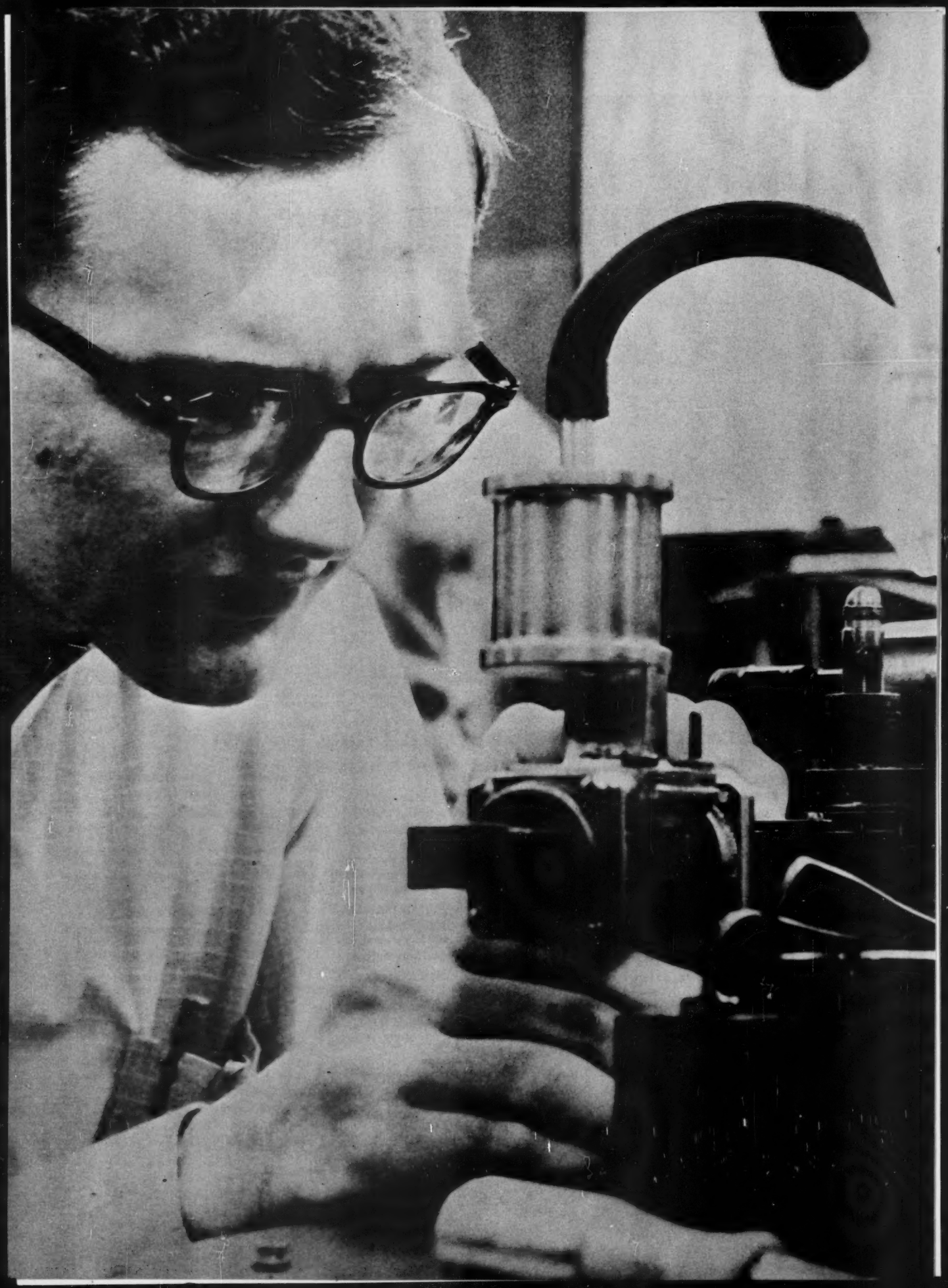
World leader in radio—first in television



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FRONTISPIECE

Alignment

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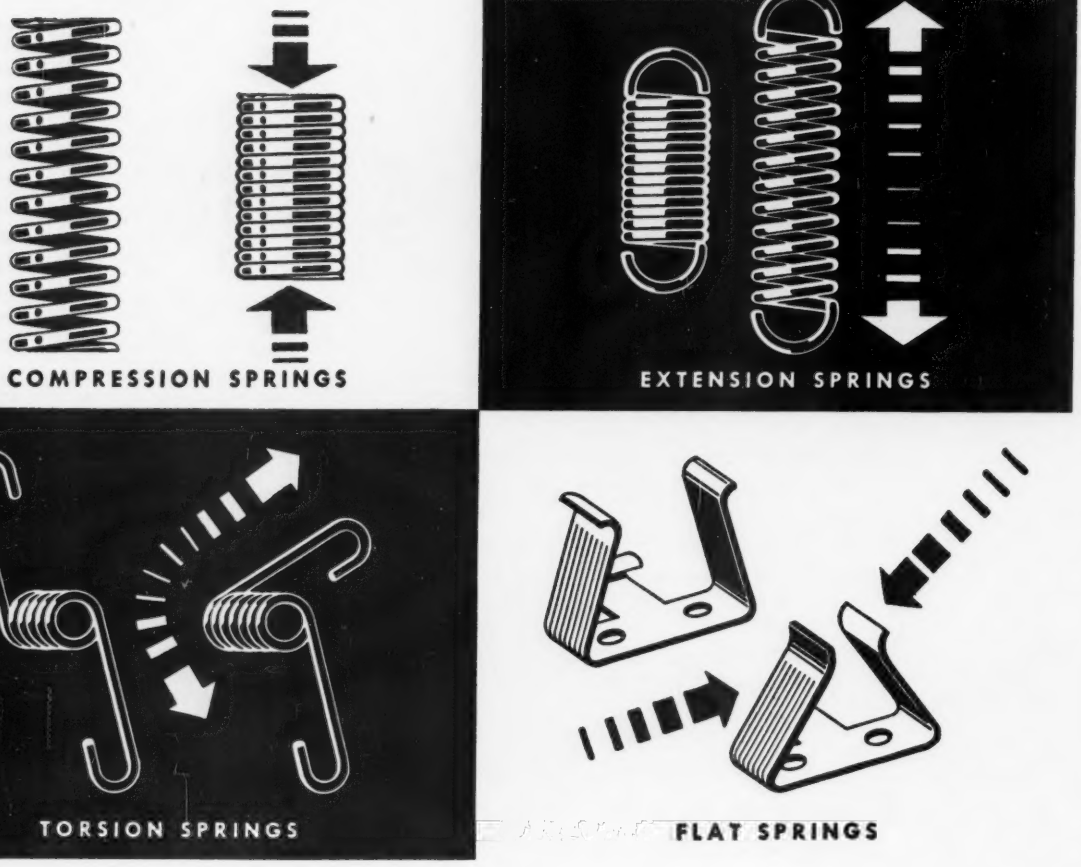

Spring Energy

in Every Direction

Wallace Barnes Springs

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Springmakers for four generations

Foreground: Boeing RB-47E, world's fastest day-or-night long-range reconnaissance plane. *Background:* Standard B-47E six-jet bomber.

What do you want most in an engineering career?

Is it room to grow? Then join a company that's growing. Boeing, for example, has grown continuously throughout its 37-year history of design, production and research leadership. There's always room up ahead—and Boeing promotes from within. Regular merit reviews are held to give you steady recognition.

Do you want long-range career stability? Boeing today employs more engineers than even at the peak of World War II. Here you'd work on such projects as pilotless aircraft, research on supersonic flight and nuclear power for airplanes, on America's first jet transport, and the world's outstanding jet bombers.

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Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas—communities with a wide range of recreational opportunities as well as schools of higher learning. The company will arrange a reduced work week to permit time for graduate study and will also reimburse tuition upon successful completion of each quarter's work.

There are openings in *all* branches of engineering (mechanical, civil, electrical, aeronautical and related fields) for DESIGN, PRODUCTION and RESEARCH. Also for physicists and mathematicians with advanced degrees.

For further information, consult your PLACEMENT OFFICE, or write

JOHN C. SANDERS, Staff Engineer — Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING

the numerically controlled milling machine

by Stephen Newman '56

In the Servomechanisms Laboratory stands a bulky giant faced by seven panels of blinking lights. The giant is a huge 28-inch Cincinnati milling machine, while the blinking lights belong to a digital computer; together they form a team, a "numerically controlled milling machine," whose control methods will probably bring about as large a revolution in industrial practices as did the mass production line. The numerical control system was developed as an Air Force project, to fill a basic need. In the aircraft industry, production is not large enough, nor stable enough, to justify the widespread use of completely automatic machines such as in the automobile industry. Such conventional automatic machines are set up to manufacture but one product, and changes could not be made except at prohibitive cost in time and money. A means of manufacturing parts was needed which could quickly and cheaply process from ten to five hundred parts, and then change over to another, perhaps entirely different part. Flexibility was the essential ingredient—flexibility with automatic control.

THE MACHINE

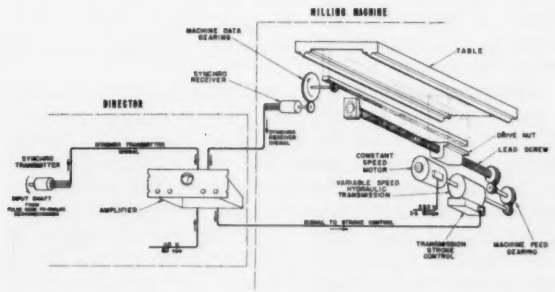
In the M.I.T. numerical control system, numerical information in the form of a tape is fed into the machine, interpreted, and used to control the milling tool's path. The complete unit is grouped into two components. The first, which may be called the "director," receives and interprets the data from the tape, and transmits commands to the actual milling machine. To do this it uses a data input system, a data interpreting system, and three decoding servomechanisms, one for each motion of the machine, and all identical. The second component may be called the "machine," which receives commands from the director, and translates them into the actual process of milling. It is composed of the milling machine proper, three essentially identical servomechanisms for moving the machine, and devices to measure the relative position of the parts.

The data input system serves to receive instructions from the tape, and to supply them to the interpretive and command units of the director. It consists of a tape reader and a set of six relay

registers. The tape reader detects holes in the tape with mechanical feelers, and sends out electrical signals to the registers. Since the machine must be constantly controlled, two relay registers are used for each machine motion; while one is in control, the other receives data from the tape reader, and thus keeps up a continuous flow of information.

From the relay registers the information goes to the data interpreting system. An electronic oscillator, which acts as a time base for the system, continually sends out pulses, which are transmitted or rejected according to the information in the relay registers, by means of seventeen "flip-flop" switches.

These pulses are now fed into a decoding servomechanism, whose purpose it is to convert the pulse instructions into the shaft rotations, which in turn drive synchro transmitters, and ultimately the servomechanisms which actually move the milling machine. The mechanical element consists of the shaft connecting the synchro transmitter, a "coder," and a small two phase servo motor. The coder generates feedback pulses, which can be subtracted from the pulses coming from the interpreting system, in a device known as the "summing register." When the sum is not zero, a small voltage is generated which moves the small servo, rotates the shaft, and brings the count back to zero. It is this feedback circuit which is the principle controlling circuit, and which makes sure the machine faithfully follows its instructions. Now information is finally transmitted through the transmitting selsyn, which is controlled by the movement of the shaft, to the working servomechanisms in the machine itself.



NUMERICALLY CONTROLLED MILLING MACHINE
TYPICAL POWER SERVOMECHANISM

Decoding servomechanism in the director ensures that commands are correctly translated from pulse form to analogue form of varying shaft angle. Pulses from the amplifier are picked up by the servomotor, which rotates the transmitter shaft one degree per pulse. A negative pulse is returned to the summing register by the coder for each rotation of the shaft. The transmitting selsyn then feeds an electrical signal into the machine's circuit, which is amplified and used to drive the working motors. The receiver selsyn under the table feeds back into the amplifier a signal corresponding to the motion of the table. This signal is compared with the transmitter signal and a corrected signal is sent to the table drive.

In the machine the electrical instructions from the director are amplified, and then sent to the large motors which actually move the cutter or the machine table. Another feedback circuit is inserted here, again to make sure that the medicine is following the prescribed path. (This takes into account any errors which might arise from inaccuracies in the large and comparatively clumsy driving motors.) In the present set up at M.I.T. the ratio of linear travel to rotation of the synchro transmitter is .0005 linear inches of travel to one degree of rotation. This is the limiting accuracy of the controlling device. Since it is much better than the inherent accuracy of the milling tool itself, it is not a factor effecting the accuracy of the combination. The controlling device's accuracy can be changed to come within any desired accuracy by decreasing the length of travel per degree of rotation.

THE TAPE

The most difficult operation in using the milling machine is construction of suitable information, i.e. the tape. The locus of the cutting tool's path must be precisely figured out, reduced to incremental line segments, specified by numbers, and put on the tape. This may take fifteen or twenty hours, or as much as a month in the case of fairly complicated figures. However, once a supply of tapes has been built up and is available, tapes can be changed as easily as the tape on a tape recorder. There is no time lost in changeover. This is where the extreme flexibility of the numerical control method comes into the picture. A machine similar to the one at M.I.T. could be kept continually busy manufacturing parts for an aircraft company, even if only a few airplanes were being built; and it could produce parts in a fraction of the time and with much greater accuracy than is now possible by even the most highly skilled machine tool operators of today.

THE MACHINE IN ACTION

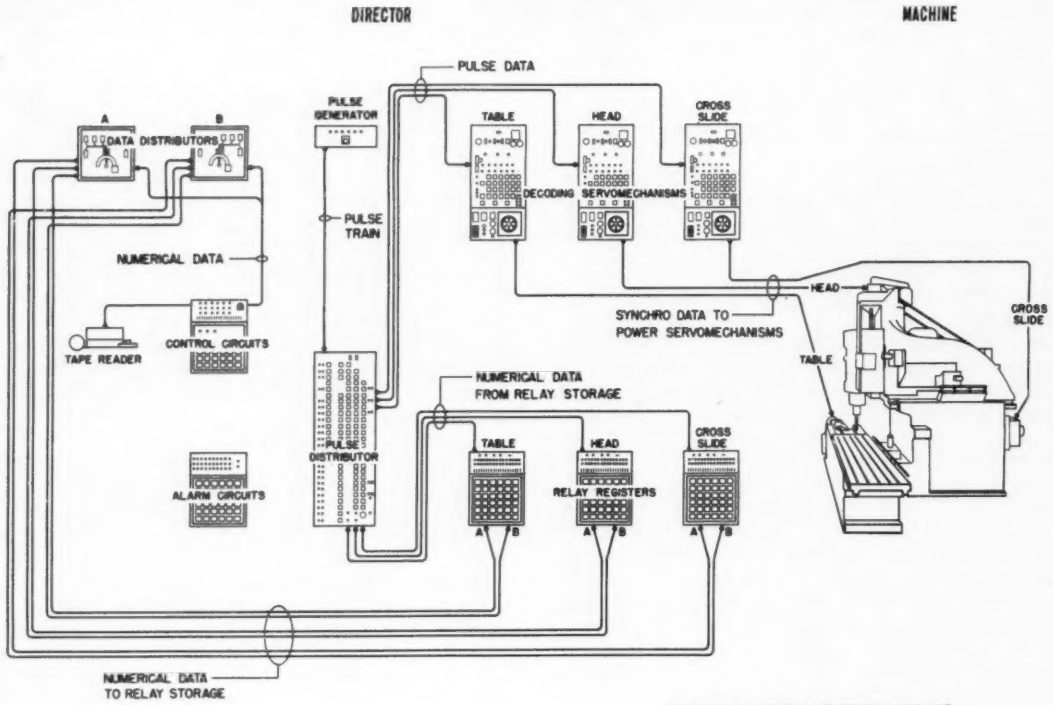
The numerically controlled milling machine's construction was completed in 1952, and it has been under test since that time. Some of its accomplishments are truly remarkable. For instance, at the request of the Air Force Cambridge Research Center it was used to mill down the male section of a Luneburg lens. This is a precise radar part, 15.960 inches in diameter, and 4.755 inches high, with a mathematically defined surface which had to be duplicated to within plus .001 inches and minus .000 inches. This kind of accuracy would be impossible to achieve by current milling methods with human control. However, since the surface was mathematically defined, it was fairly easy to do by the numerically controlled milling machine. The breakdown of time required is as follows:

tape preparation	6 hours*
set up of work	2 hours
roughing operation	9 hours
final cut	2.5 hours

A total of only nineteen and one-half hours to do an impossible job.

As an example of the time saving involved in the operation, the milling machine was used to make a forward drag strut from a standard forging. The time breakdown was as follows:

*Figures from: "A Numerically Controlled Milling Machine," a final report to the Air Force on construction and initial operations, page 16.



NUMERICALLY CONTROLLED MILLING MACHINE
FUNCTIONAL BLOCK DIAGRAM

automatic milling operation	0.4 hours*
manual intervention	0.25 hours
total machine operation/part	0.65 hours
tape preparation time	16.0 hours
work set up (special fixtures used)	2.0 hours
total set up time/run	18.0 hours

It takes, with conventional methods, twenty-seven hours of set up time, and two and eight-tenths hours of milling time to machine the same part. Thus if two hundred struts were being made, the total time of manufacture with conventional methods would be five hundred eighty-seven hours; the total time with numerical controlled methods would be one hundred sixty-six hours, and the tape would be available for future operations. The time saved in this operation alone would amount to four hundred twenty hours—ten and one-half man weeks of working time, more time than is contained in a summer vacation!

OUTLOOK

The good points of the numerically controlled method are many, and it seems certain to come into general use within the near future. In fact, several companies have already entered the field of numerical control. The speed and flexibility of the method have already been mentioned. In addition, there is its ability to control machines at a distance. In the M.I.T. set-up the director was but a few feet from the milling machine; it could just as well have been a mile, or three thousand miles away. Indeed, it is possible to conceive of a few director units in, for example, New York City, running thousands of machines throughout the country.

However, before the picture takes on too rosy a view, let it be stated that the numerical control system is not a panacea. It does have drawbacks, some of which are prohibitive in nature. For instance, non-flexible automatic machines are better suited to those cases of mass production where their initial cost may be amortised by tens or hundreds of thousands of production units. These machines are in general faster and more efficient at their one particular job than an all-purpose numerically controlled tool. At the other end of the pole, the director itself is expensive, running to about the cost of its machine-tool mate, or in the M.I.T. system, between 40 and 60 thousand dollars. However, in time this may drop to ten thousand dollars.

As for its effect upon labor, it is difficult to see any great problem arising from this latest production development. The mass production tools of the automobile industry create jobs for millions of men, rather than create unemployment. The control apparatus will create a new field for electronic technicians, for highly skilled men will be needed to service such complex machinery. The future of numerical control is bright and imminent. Perhaps we shall live to see the day of the numerically controlled automatic factory!

*Op. cit., page 19.

A CAMPUS-TO-CAREER CASE HISTORY

Bob Wilson uses a "breadboard" circuit, studying the electrical properties of a carrier system.

"My first assignment at Bell Labs"

Fresh out of school, Bob Wilson, '53, was put to work on a Transistor project at Bell Laboratories. He explains why he never had time to be awed.

(*Reading time:* 39 seconds)

"In some ways it was hard to believe. I had received my B.E.E. at the University of Delaware in June, 1953, and a week later I was working in the world-famous Bell Laboratories.

"But I didn't have time to be awed because they put me right to work. They gave me responsibility fast.

"My group was working on the experimental application of transistors to carrier systems. My assignment was the electrical design of a variolosser for the compressor and for the expandor to be located in the terminals.

"The supervision I received and the equipment I had were tops. I quickly discovered that I had to rely on my ingenuity as much as on the college courses I had taken. Perhaps that's one reason for the great new discoveries continually turned out by the Labs.

"Now I'm in the Communication Development Training Program, continuing my technical education and learning what all the Laboratories sections do and how their work is integrated.

"In a year I'll be back working with the group with which I started."

. . .

Assuming responsibility fast is a common experience among the engineering, physical science, arts and social science, and business administration graduates who join the Bell System. Bob Wilson went with Bell Laboratories. There also are job opportunities with the operating telephone companies, Western Electric and Sandia Corporation.

BELL TELEPHONE SYSTEM

tech engineering news

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Massachusetts Institute of Technology

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from the editor's notebook

As audio lines listeners know, next year the Saturday evening broadcasts of the Boston Symphony Orchestra are to be carried on the NBC Network. Normally we would be very happy over this additional source of revenue for our wonderful local orchestra; there are however several reasons why we're not.

When we were unable to attend the concerts, we enjoyed listening to them as broadcast by WGBH. These broadcasts have always been the technically finest possible concert broadcasts, but their value may be greatly lessened by the new arrangement with NBC. Present plans call for NBC's carrying only one-half the concert, the rest to continue to be carried by WGBH as before. This seems a most unworkable arrangement for the local FM listeners who will have to change stations in the middle of the concert. In addition there is no reason to suspect the broadcasts will be technically any better than the rather poor quality of the NBC Symphony broadcasts of past years. Indeed, the tentative arrangement calls for the signal to be sent down to New York for monitoring, then to be sent back up here for broadcasting—all over 5 KC lines!

Either the local NBC station should broadcast the signal directly to its FM transmitter, using the excellent microphoning of WGBH, and broadcast on FM anyway the complete concert, or WGBH should be allowed to continue to serve the discriminating listeners who have gone to the expense of purchasing FM tuners. These listeners, many of whom are loyal supporters of the orchestra, deserve nothing less.

We urge you to write George E. Judd, Manager, Boston Symphony Orchestra, Symphony Hall, Boston, and give him your opinion.

D.L.K.

Edict

Hear ye, hear ye, know ye all men by these presents that whosoever shall deal with WMIT acting as a member of our organization or who is a member of T.E.N. and is approached by a member of WMIT in some matter related to the activities of T.E.N., shall at all times deal with WMIT members acting as such in a spirit of constructive cooperation, and shall not be rude, brusque, or impolite.

PETER EMBREE, General Manager

A Statement of Policy

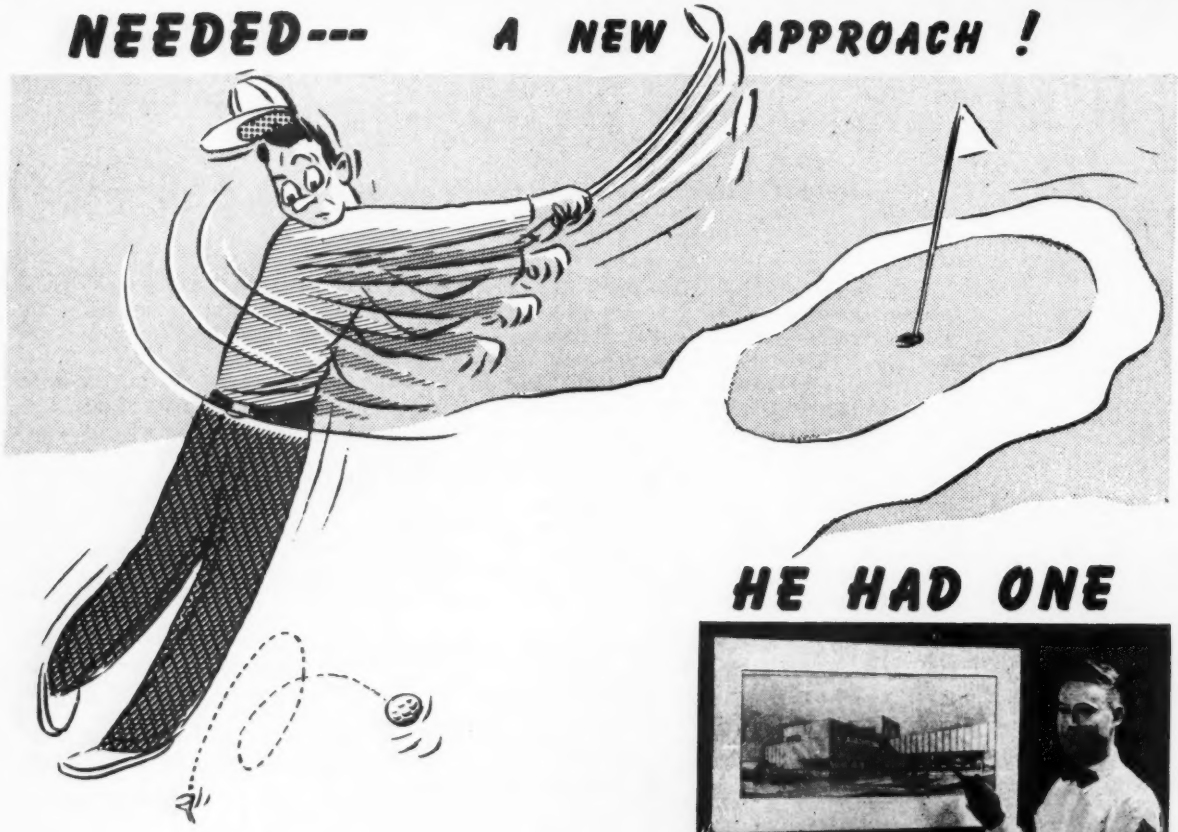
Now that the somewhat tangled situation regarding the audio lines at MIT has been satisfactorily straightened out, a statement of TEN's function in the audio line field seems to be in order.

In the past year, members of our staff have participated in the laying of Institute telephone cables, with the result that TEN now has the use of underground telephone pairs from Walker Memorial to East Campus and the Graduate House. We are, as a public service, running these pairs as balanced audio lines to interconnect the various dormitories and any interested labs with each other, and eventually to provide a feed from the Music Library, whenever desired. We will be responsible to the Institute for the cables and the Music Library feed, and will maintain the cables and necessary monitoring equipment at our own expense. We do not intend to initiate programming at the TEN office or to take any part in the operation of audio lines within the various houses.

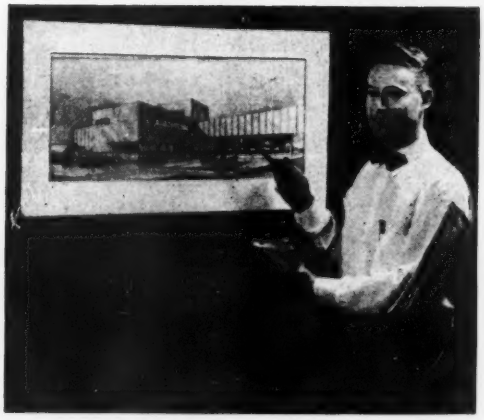
It should be emphasized, however, that the primary function of this organization will continue to be the production of an undergraduate technical magazine, and that this "good will" service will be carried on only as it does not interfere with this primary function, and actually remains a source of good will.

R. D.

NEEDED--- A NEW APPROACH !



HE HAD ONE



LAMAR A. RAMOS, JR.,
Sr. Design Engineer—Airplane Engineering Division
B.S.P.E. Lousiana State U. 1941
B.S.A.E. Georgia Inst. of Technology 1947

Seen here examining the architect's sketch of our recently completed Wind Tunnel, Lamar's approach in solving complex and often unique aerodynamic problems has marked him as an engineering asset to M.A.C.

In 1947, he was first assigned to the XF-85 "Parasite" fighter, model of which he is holding above, and has since contributed his aerodynamic talents to most of our airplane engineering projects. He is presently a Group Leader concerned with the aerodynamic design of aircraft proposals. We need more young engineers like Lamar Ramos, *engineers with a new approach.*

VARIETY OF WORK is one important advantage of joining M.A.C.'s engineering team. The career opportunities in our three engineering divisions—AIRPLANE, HELICOPTER AND GUIDED MISSILE—are so varied that practically all types of engineers may be placed in a satisfying assignment, one charged with technological impact and challenge to ability. Every effort is made to place each engineering graduate in the division and assignment of his choice.

VARIETY OF LIVING in beautiful suburban St. Louis can also be yours. M.A.C. engineers are encouraged to seek advanced degrees at one of St. Louis' fine universities. The educational, cultural, medical and recreational facilities available in this city are unparalleled elsewhere.

If you're looking for our type of engineering—we're looking for you. Check your Placement Office for dates when our representative will visit your school. Ask him about the McDONNELL GRADUATE STUDY PLAN. You may also write to:

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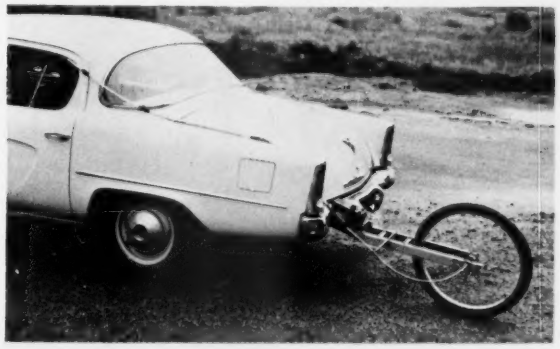
consumers' research

What it is and how it functions

by Edward J. O'Brien '57

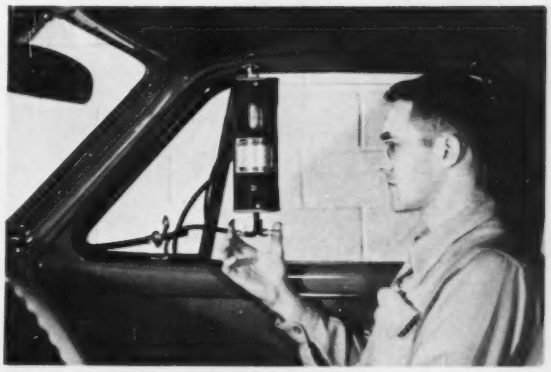
Ever since primitive man first swapped surplus meat for fish caught by his neighbor, or bartered a handmade weapon for a pelt, trade has been a topic fundamental to society. Buying and selling in this country was generally limited to necessities during the period extending from America's inception in 1776 to late in the 19th century. People simply worked too long and too hard to have much concern about luxuries and in addition could not afford them. The general store supplied every conceivable item on a shopping list, while traveling peddlars fulfilled other infrequent needs that arose. As a result, competition was practically unheard of and was actually unnecessary.

When industry began to flex its muscles and America was on the way to becoming the economic giant that it is today, people suddenly found their buying powers increased; powers which reached a high point in the booming twenties. Then the depression suddenly snapped people out of their dream. A growing concern over the value of the dollar became apparent, and competition as we know it today was born. Now manufacturers not only had to produce, they had to sell. The means for selling was an obvious one—advertising. Industries tried to outshout and outclaim their rivals in pursuing the buyer's favor, leaving the purchaser rather befuddled when it came time to make a choice.



Fifth wheel in operating position.

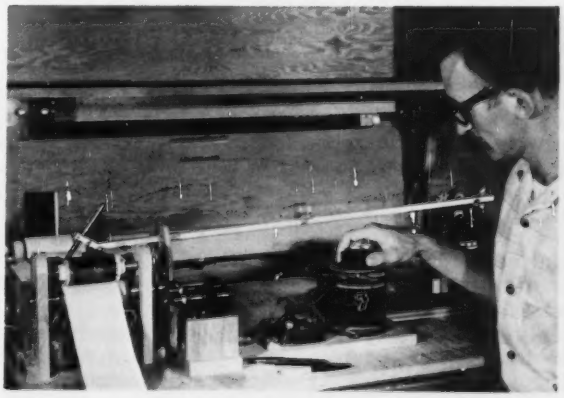
As an answer to this new problem, the book, *Your Money's Worth,* by Stuart Chase and Frederick Schlink, appeared in the late twenties. While no one act brought about an increase of interest in the consumer, this book helped as much as anything else in the attempt to gain for the buyer a true value for his dollar. A flood of inquiries from readers of this book resulted in the establishment of an organization to seek answers to these queries: Consumers' Research. Operating on a nonprofit basis, it endeavors to test the relative quality of numerous and varied items, and to report results in the monthly *Consumers' Research Bulletins.* Subscribers are thus enabled to make the best choice when they buy.



Calibrated gas-tank for mileage test.

The first step in their procedure is to compile a list of information sought by the readers, as well as the brands which are most widely known and distributed. Purchases of these items are made on the open market. Engineers then outline the actual testing methods to be employed, and the tests are

Ball Point pen tester.



Technicians at work in one of CR's Laboratories.

carried out, often over a long period of time. CR's experts then grade the various products as A: Recommended; B: Intermediate, or sometimes C: Not Recommended. A full report of the results is written up by one of the engineers, and appears in the Bulletins.

An interesting step in this procedure is the actual testing methods. Frequently special testing devices must be improvised which will enable the testers to determine the qualities of an item.

One such device is the so-called "fifth wheel" used in computing the following information regarding automobiles: acceleration, braking distance from a given speed to a full stop, miles per gallon of gasoline, and accuracy of the readings of the car's speedometer and odometer. The "fifth wheel," shown in the accompanying picture, is a bicycle tire clamped onto the rear bumper. A flexible shaft leads from the wheel to a recording unit located on a shelf in front of the rear seat. By means of this connecting shaft, a recording drum can be made to rotate with a speed directly proportional to the angular velocity of the bicycle wheel. A synchronous-reed-driven d-c timing motor (a constant speed battery-operated device) located in the recording unit actuates a plunger through short electrical impulses delivered every half second, much like a spark gap timer, but making a series of dots instead of holes on the drum. Thus, when the car is traveling at constant speed, equal distances between dots results, but as the car accelerates this distance increases, and it likewise decreases as the car decelerates. As the drum rotates, the timer moves in a direction parallel to the axis of the drum, in the same manner as the stylus on the Edison-type phonograph. It is a simple matter to calculate the top possible acceleration and deceleration of an automobile, and the accuracy of the car's instruments.

The "fifth wheel" is also employed in the mileage per gallon tests. The recording device is able to count the revolutions made by the fifth wheel, and can easily measure the exact distance traveled in a given interval. A container which holds one tenth of a gallon of fuel is connected to the fuel pump. When the car has reached constant speed and the gasoline level is at the calibration, the test is begun. The electric counter is automatically switched off when the gasoline is exhausted. The number of revolutions, dimensions of the wheel, and known amount of fuel consumed can easily be converted to miles per gallon.

Another item of widespread use tested by CR is the ball point pen. Most of the early tests dealt

The recording instrument, R, with the chart drum, D (used for acceleration tests and brake tests), and, at the left of the drum, the electric counter, C (used for gas-mileage tests).

with the lasting qualities of the ink, a major problem six or eight years ago. Recently other characteristics have been submitted to experiment. An obvious one is the quantity of writing possible from ball-point cartridges. To find out the relative quantities supplied by various brands, CR built the pen tester shown in the accompanying picture. By means of this, a pen "writes" on a rotating drum until it is exhausted, and the amount of writing is measured. Two other unusual devices have been made to test a feature not quite as obvious as the aforementioned; namely the working qualities of mechanical-type pens. Tested are two major types of mechanisms: the injector type, and the type which works by a knurled knob at the top.

Improvements have been made in testing fading qualities of ink, and now a Fade-Ometer has been built which makes use of an arc lamp to accelerate the fading which would be time-consuming if done by sunlight.

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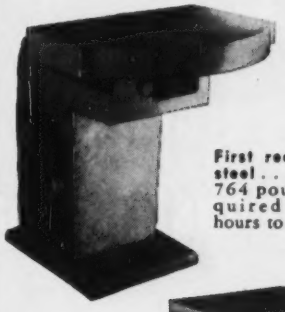
3. **Steel costs a third of iron.**

Ultimate savings are limited only by the ingenuity of the designer.

SIMPLIFIES DESIGN CUTS FABRICATING COSTS WITH WELDED STEEL

The successful industrial designer is one who can suggest ways of cutting the costs. That's why the engineer who knows how to utilize savings through welded steel finds his designs readily accepted.

Here, for example, is how steel design has eliminated 356 pounds of metal in the manufacture of the base for this machine. All former machining has been eliminated. There are no bolted joints to cause leakage of coolant. Cost of manufacture has been cut 20%.



First redesign to steel . . . weighed 764 pounds. Required only 31 hours to fabricate.

Final design more compact in construction, weighs 692 pounds . . . takes less floor space, requires only 24 hours to fabricate.

Original design required 1048 lbs. of castings bolted together. Each casting required costly machining and fitting.

HOW TO PUT STEEL'S SAVINGS TO WORK—

DESIGN DATA for welded construction is available to engineering students in the form of bulletins and handbooks. Write:

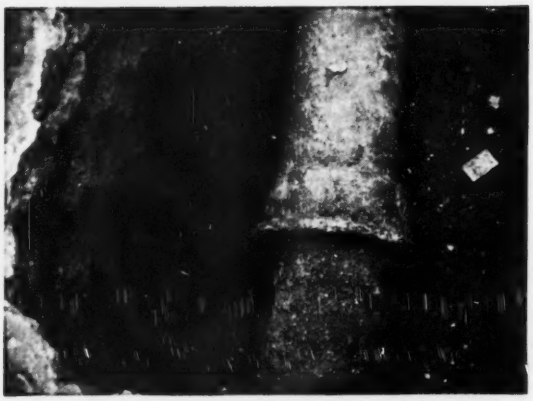
THE LINCOLN ELECTRIC COMPANY

Cleveland 17, Ohio

THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

Ball-and-socket joint cast iron pipe for water main crossing river at Newark, Ohio.

Where installations are planned for long-term service to assure low cost per service year, engineers rely on cast iron pipe as a dependable and adaptable material. Consequently, it is specified for a wide variety of applications, both utility and industrial, including water supply, sewerage, fire protection, process industries and many forms of special construction. Long life and low maintenance cost are *proved* results of the high beam-strength, compressive-strength, shock-strength and effective resistance to corrosion of cast iron pipe. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3, Ill.



Cast iron water main still functioning in Philadelphia after 135 years of service.

CAST IRON PIPE SERVES FOR CENTURIES

Ever Study

TERRESTRIAL ENGINEERING?

Probably not. As far as we know, there isn't such a term. Even so, the terrain of a manufacturing plant may have a vital effect on the design and location of its engineering equipment.

It certainly did in the case of our Belle, West Virginia, plant, which is just across the road from a flat-topped hill, 750 feet high.

Perhaps you'd like to match wits with Du Pont engineers, for we feel that this problem was interesting—and its solution ingenious.

Briefly, the situation was this: Carbon dioxide was to be removed from a mixture of gases by bringing them into contact with water in "scrubbers" operating at 450 psi (gauge). The inlet gases contained about 25% CO_2 by volume. Because of its greater solubility, most of the CO_2 would leave the scrubbers dissolved in the water.

It was necessary to reduce the pressure of this water to atmospheric and recover the dissolved carbon dioxide, since CO_2 was needed for use in a chemical synthesis. The degasified water then had to be pumped back into the pressure scrubbers, to repeat the scrubbing cycle.

Still like to match wits? How would you design an economical closed system for this scrubbing water? After you've thought out your solution, you might like to compare it with the one given below.

Du Pont engineers made use of the precipitous terrain in this way: pressure on the water leaving the scrubbers was sufficient to force it up to the top of the hill for CO_2 recovery. The returning water thereby provided a pressure of approximately 325 psi (750 feet of head) at the base of the hill. This gift of pressure on the suction side of the water pumps resulted in considerable energy saving.

Do unusual problems such as this one challenge you and stir your enthusiasm? If they do, we think you'll be interested in technical work with the Du Pont Company.

Watch "Cavalcade of America" on television

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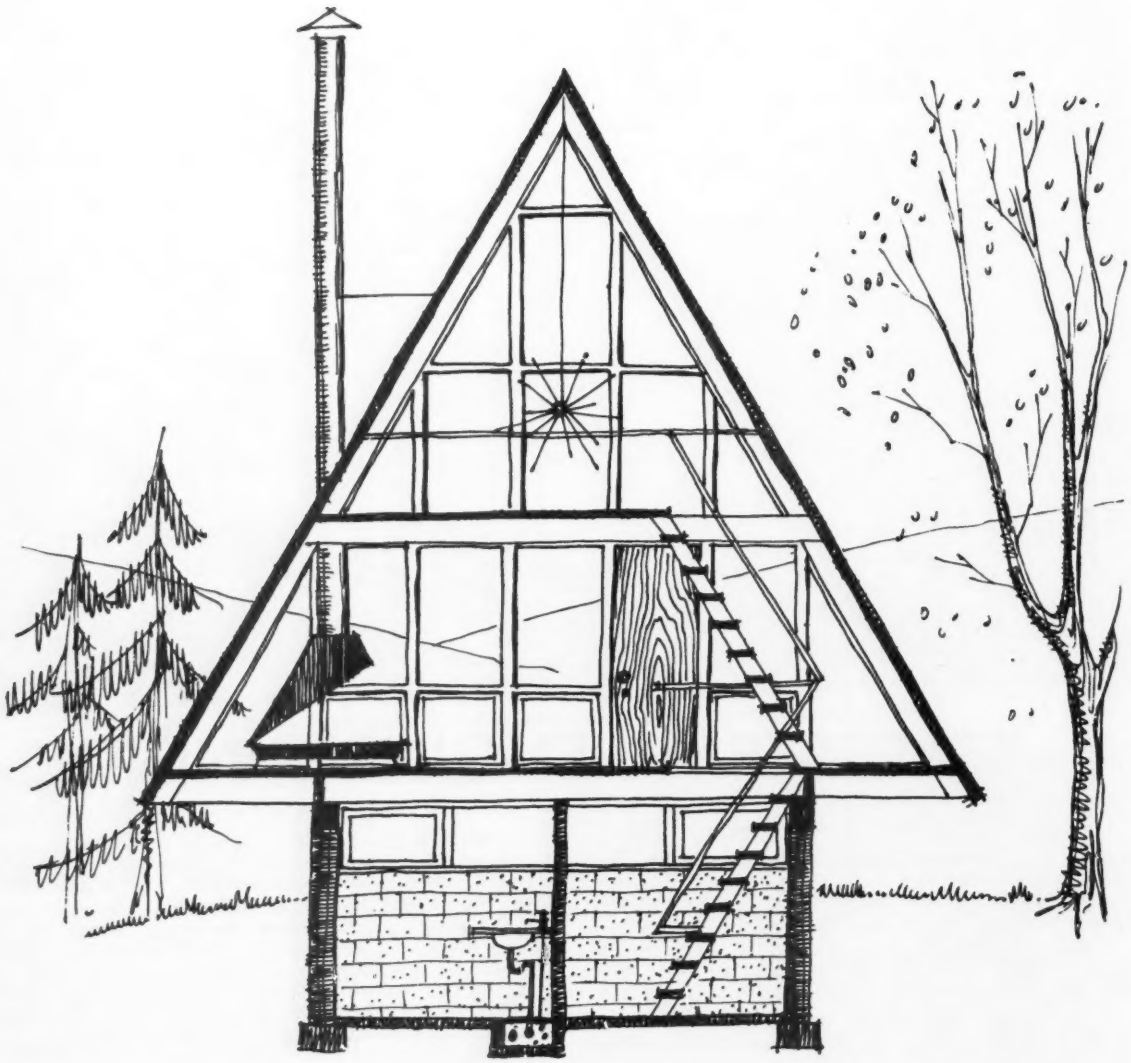
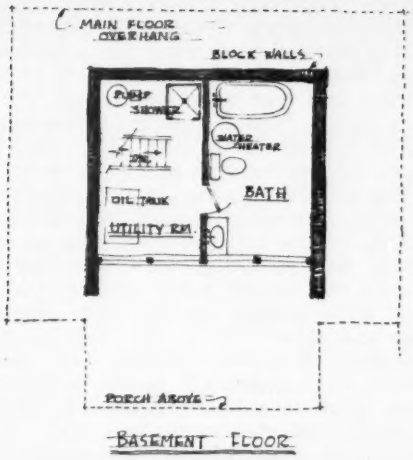
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

überhängengögel

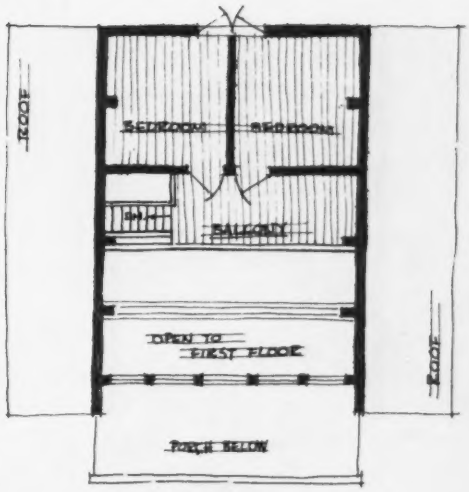
by Henrik Bull '52



The idea began when John Flender looked down at some doodles I was making at the drawing board while waiting for larger scale architectural inspiration. "Why don't we build that in Stowe next summer," he said, "it looks easy enough to put together and think of all the money we would save on skiing." This agreed, we talked back and forth at length with the enthusiasm and realism of small boys who decide to set up a corner store and become millionaires



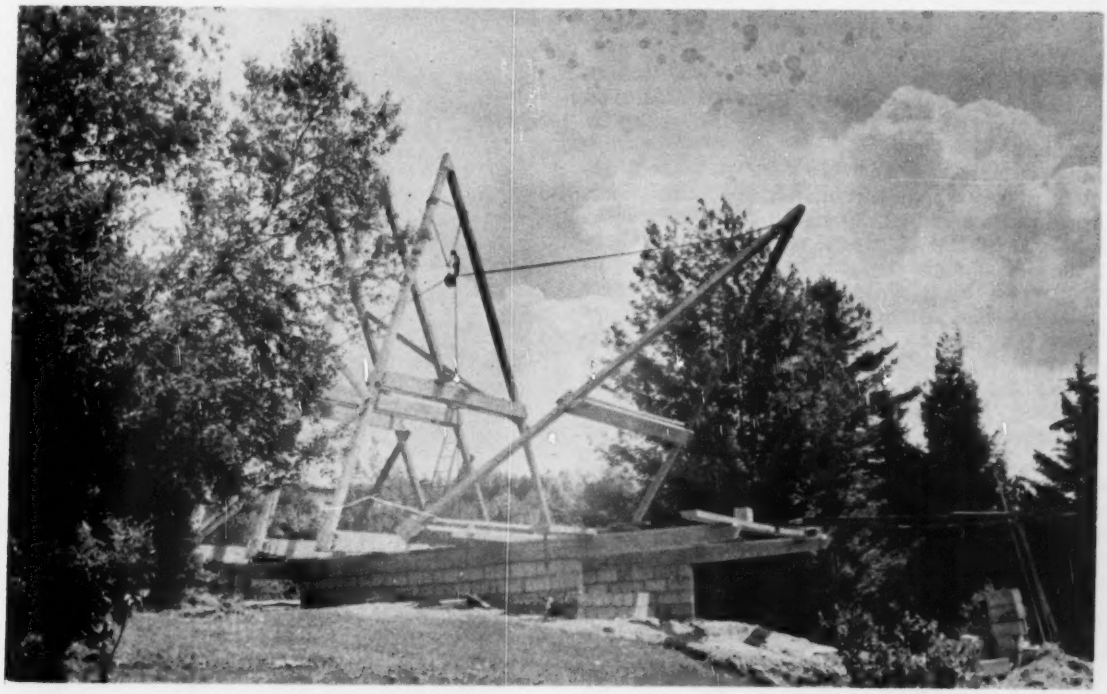
BASEMENT FLOOR



BALCONY FLOOR PLAN

selling marbles to their colleagues. The idea didn't die easily with John, however, and the "A" frame vacation house had been germinating in my mind since I first considered it in the summer of 1951. Many primitive peoples had built such structures, ranging from chicken coop size up, and it was certainly an easy way to get space under a roof economically. We estimated that the house would cost about fifteen hundred dollars, which turned out to be pretty close for the basic structure. As the idea gained momentum, we were joined by Mike Wall and his new bride Bettina. This, of course, brought into the program many amenities which hadn't originally been scheduled. Most important among these were complete modern plumbing and an automatic heating system. These doubled our estimated costs, but were rationalized by John and Mike (business administration men), from the possible resale standpoint. Bettina, a professional artist in Boston, did some watercolors to show the local bankers when asking for a loan. Yankee conservatism prevailed, however, and the first

The fourth of six structural frames is here being raised during the Summer of 1953.



The southern wall is wholly glazed and overlooks the cantilevered porch.

bank we approached declined our proposition. The second bank seemed to have a more venturesome spirit, though, and the project was underway. John's brother, Richard, who was stationed in Europe in the Air Force joined the group by proxy about this time.

More complete drawings were prepared, including a large living room on the main floor. This all-purpose room, 20 by 26 feet, enjoys the full height of the southern window wall (there are no line-of-sight neighbors for 14 miles, as a comfort to the inhibited). Two small bedrooms for the married couples are located on a higher balcony floor which extends only partially forward from the north wall into the larger space. A ship's ladder parallels the roof pitch to the main floor. The utility and bath rooms were located below grade (and frost line) in an effort to solve the freezing pipes problem. Draining plumbing after week-ends had proved an awful chore in houses we had rented previously. A porch cantilevers out on the main girders on the south side. Made of 2 by 6 lumber on edge, with one inch spaces between, it is as self-shovelling as the 60 degree roof.

The longest new timber available in the state of Vermont is 26 feet, and this became the basic dimension for the supporting girders and each side of the equilateral frames. All structural members were carefully analyzed. The cantilevered construction with "stressed-skin" floor and roof effected a saving in lumber of about 25 per cent. The erection time was also considerably cut down, since weak and complicated joints between walls and roof were eliminated. The total framework of A frames was cut, assembled and erected by two of us in four days. This phase was most interesting and posed the most problems. The 8 by 10 girders, which weighed 700 pounds apiece, were positioned with the help of the derrick on the local wrecker. The A frames were built flat on the girders, the first being raised with the help of a gin pole, and succeeding ones with pulleys on the first. Sheathing, flooring, and shingling (1 inch thick Canadian cedar shakes) were more tedious jobs. About 90 man days were consumed in the construction, including finishing and such prosaic work as laying drain tile from the septic tank. The only professional labor involved was in excavation (by power shovel), pouring the cellar floor, and glazing of the larger glass areas. Otherwise "Sunday" carpentry and masonry prevailed.

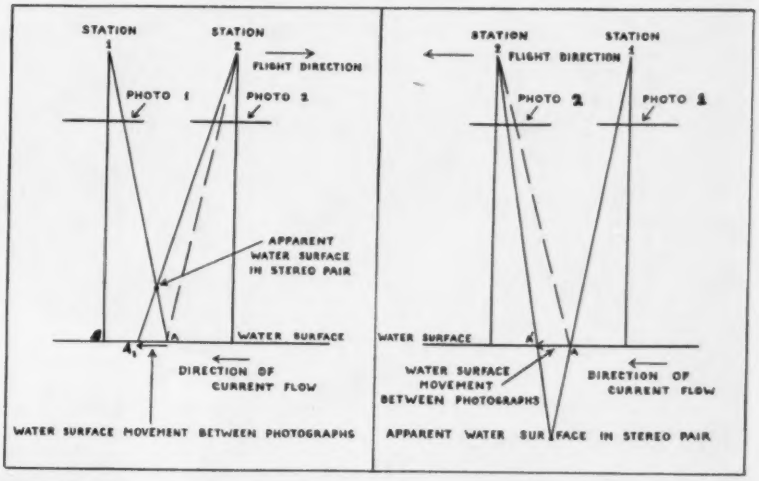
After a summer and fall of week-end work, the house was officially "warmed" last New Year's Eve. Since that time, each week-end has seen from six to eleven people staying there in sleeping bags. The skiing has been too good to furnish much incentive to accomplish the finishing touches, and it looks now as if it will be mid-May before the snow melts.

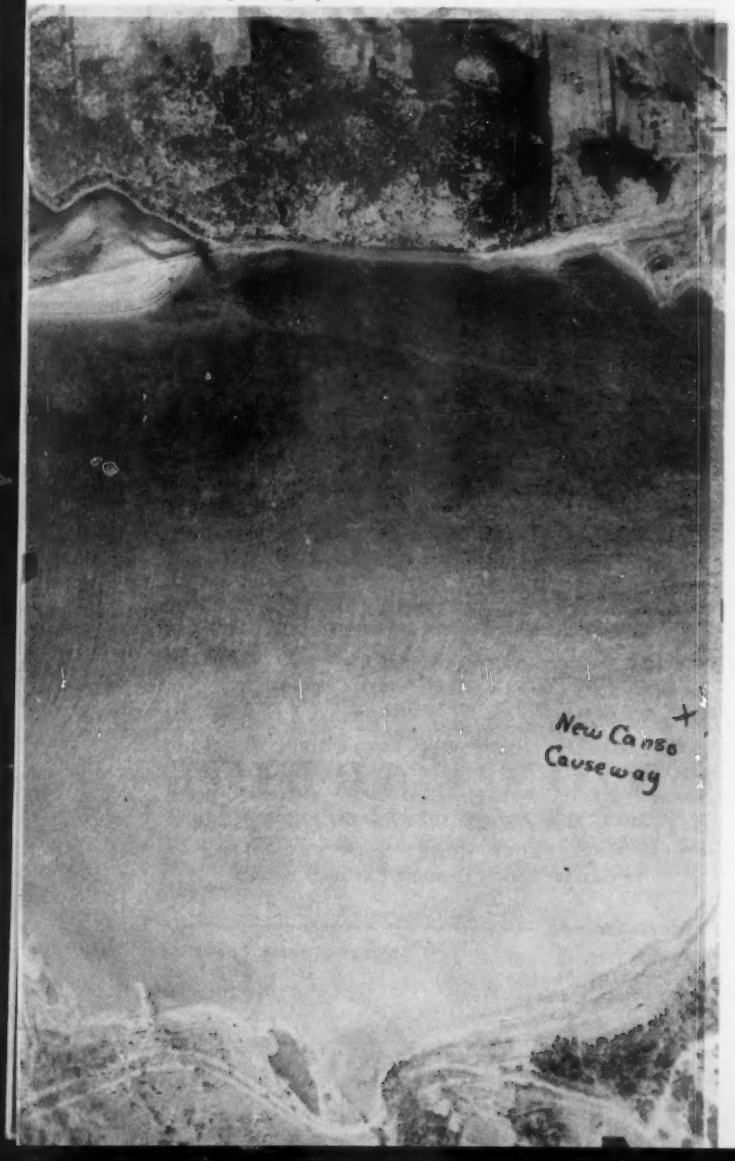
The house is well situated above a valley in Stowe.

air photo interpretation

by H. L. Cameron, Nova Scotia Research Foundation

Prof. Cameron is well known to those MIT students who have taken his course in aerial photography at the MIT Geology Summer Camp in Nova Scotia. He is widely recognized for his aerial photography work and the uses to which he has put aerial photographs. A large part of Nova Scotia has been photographed under his guidance, and the photographs thus made been used for purposes such as those discussed in this article.





Tidal current flowing through Strait of Canso, Nova Scotia. Restricted by new causeway at X. Note apparent raised water surface due to water movement between photographs.

The majority of people today are aware of the great developments in aerial photography for military reconnaissance. They have seen numerous examples of war photography, particularly "before and after" vertical photos, the most striking of which were those of Hiroshima, and more lately, of the coral island obliterated by the H Bomb blast. However, few people are even remotely aware of how many fields of use have been found for air photos, and how their daily lives may be affected by these developments. Even in the fields of engineering, where most workers are aware of the survey methods, there is a general lack of appreciation of these new developments. This short article is designed to review some of these, with particular emphasis on a pair of more unusual ones.

Aerial Photography Techniques

First a word on air-photography and aerial cameras. Air-photos for technical use are of three general types (1) Oblique (2) Vertical (3) Continuous Strip. Obliques are taken with the camera pointed outward and downward at an angle to the horizon, which may (high oblique) or may not (low oblique) appear in the photograph. They resemble the view from the window of a commercial aircraft, and are thus the most familiar looking, but on the whole, the least useful of airphotos. Verticals are taken with the camera pointed staright down, and when taken in overlapping sequence are the most useful and standard form of photography. Continuous strip photography is a development of the old panoramic camera. The film is wound past a slit at a speed synchronous with the ground speed of the aircraft, and the image is literally rolled onto the film. The chief advantage of this method is that photography is

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EVER WATCH a power shovel bite into earth and rock? And wonder how the teeth of the steel bucket can endure such punishment? The amazing answer is that the teeth not only endure such treatment—they actually get harder because of it!

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possible at very low levels and very high speeds. Relative speeds of 1000 miles per hour, and heights of twenty-five feet have already been used successfully. By using two lenses, one pointing slightly fore and the other slightly aft, stereoscopic coverage can be obtained. A combination of vertical and oblique, using a bank of three cameras, one vertical and two oblique wing-cameras pointing outward at 30° from the horizontal, gives horizon to horizon coverage. This tri-camera method has been much used for small scale air-navigational charting of remote areas, such as the Sahara Desert and the North West Territories of Canada. In standard vertical photography the camera is electrically operated, with the shutter being tripped and the film advanced at such a rate that each photo overlaps the next by some 60%. This overlap gives, in effect, a right and left hand view of the ground, such as would be seen by a giant with eyes as far apart as the two camera positions, and as tall as the altitude of the photo aircraft. By using a stereoscope to permit our eyes to assume the same position as the lens we can obtain a most striking three dimensional view of the ground surface. It is this effect which permits of making vertical measurements and the drawing of contours. Stereoscopic viewing even has a built in exaggeration of the vertical dimension which creates the same effect as the actual vertical exaggeration built into most terrain models.

Photograph Applications

The ability to extract information from the stereo view is a much discussed art. There is, of course, a tendency for the main field of interest to obscure other details. The geologist sees and traces the pattern created by the eroded edges of stratified rocks, with their folds and faults. The hydraulic engineer notes watersheds and drainage basins, stream gradients and dam sites. Foresters count trees, plot species, correlate terrain and growth, and note sites for roads and camps. Soil experts map soil types, note wet and dry areas, plot glacial and river deposits, map crops and land use. Geographers study man's activities and explain them in terms of soils, forests, climate, drainage and transport. Geomorphologists study land forms typical of deserts, glaciated areas, mountains and coastlines. Engineers seek sites for towns, airports, dams, construction materials and seaweed beds. Archaeologists and historians find ready made plans of historic sites, known and unknown. The list grows longer day by day and will no doubt continue to do so for some time to come.

In connection with the work of the Nova Scotia Research Foundation's Photogrammetry Division, the writer has had an opportunity to use aerial photos in a number of these fields, including structural geology, geomorphology, glacial geology, seaweed surveys, land use, water current velocity measurements, and historic sites. For their interest, as being unusual, brief notes on water currents measurements and historic sites are given below.

Stereoscopic Effects

A brief consideration of figures 2 and 2A will demonstrate that every object shown in a pair of overlapping photos is registered by two rays, one common to each photo. On viewing the prints stereoscopically the two images are fused to form a single image which appears at a certain distance from the eyes. The same effect is obtained when a finger is held up before the eyes, the finger being the apex of the triangle whose base is the distance between the eyes. It is obvious that the triangle will vary with the distance of the finger or the object, with the apical or parallactic angle growing smaller as the object becomes more remote. Objects the same distance from the eyes have the same parallactic angle, as for example, all points on a sheet of paper held before the face, or a water surface viewed in vertical air photos. The ability of the eyes to see innumerable points at the same time and fuse their double images at their proper (apparent) distances, gives us the ability to perceive depths, or to see three dimensionally. All goes well if the objects are stationary, and even if motion is present, such as watching your horse come in last, no difficulty is experienced, except perhaps a lack of clear perception of background. Photography is a different story, as is all too well known by those who have tried snapping moving objects. True enough, high speed shutters can freeze motion and background, but in the case of successive shots the movement is apparent against the background frame of reference. In the case of moving water, as shown in Figures 2 and 2A, movement can be shown to result in false parallax, or displacement of our parallactic triangle. If the movement of the water is opposite to that of the aircraft the rays form a triangle whose apex is closer to the eyes than it would be if the water were at rest. Conversely, if the water movement is the same as that of the aircraft the apex of the triangle is farther away.

3-D Tidal Currents

The stereoscopic effect is startling, as shown in Figures 1 and 3. Figure 1 shows the tidal current flowing through the Strait of Canso, Nova Scotia, partially constricted by the new causeway under construction to link the mainland with Cape Breton Island. The apparent water surface is nearly two hundred feet high. Figure 3 is a view of Petite Passage, Digby County, Nova Scotia, showing the tidal current created by the phenomenal tides of the Bay of Fundy. To measure the current velocity it is only necessary to measure the apparent height or depth of the water, from normal sea level or river bank. This is done using a floating dot parallax bar, consisting of two small dots on plastic strips, one fastened to a rigid metal bar, the other to a moveable section incorporating a micrometer device for measuring the separation of the dots. Each dot is placed exactly over the same image in the two photographs and on stereoscopic fusion becomes a single dot resting on the object. If the dots are brought closer together the fused single dot appears to come closer to the eyes; if they are separated the dot appears farther away, while the stereo image remains in one position. If the view is aerial, the dot appears to float into the air or sink into the ground, hence the name, "floating dot." Reference to Figure 2A will show that the displacement of the point A to A, will be the exact movement of the movable dot in

Tidal current flowing through Petite Passage, Digby County, Nova Scotia. Note apparent depression of water.

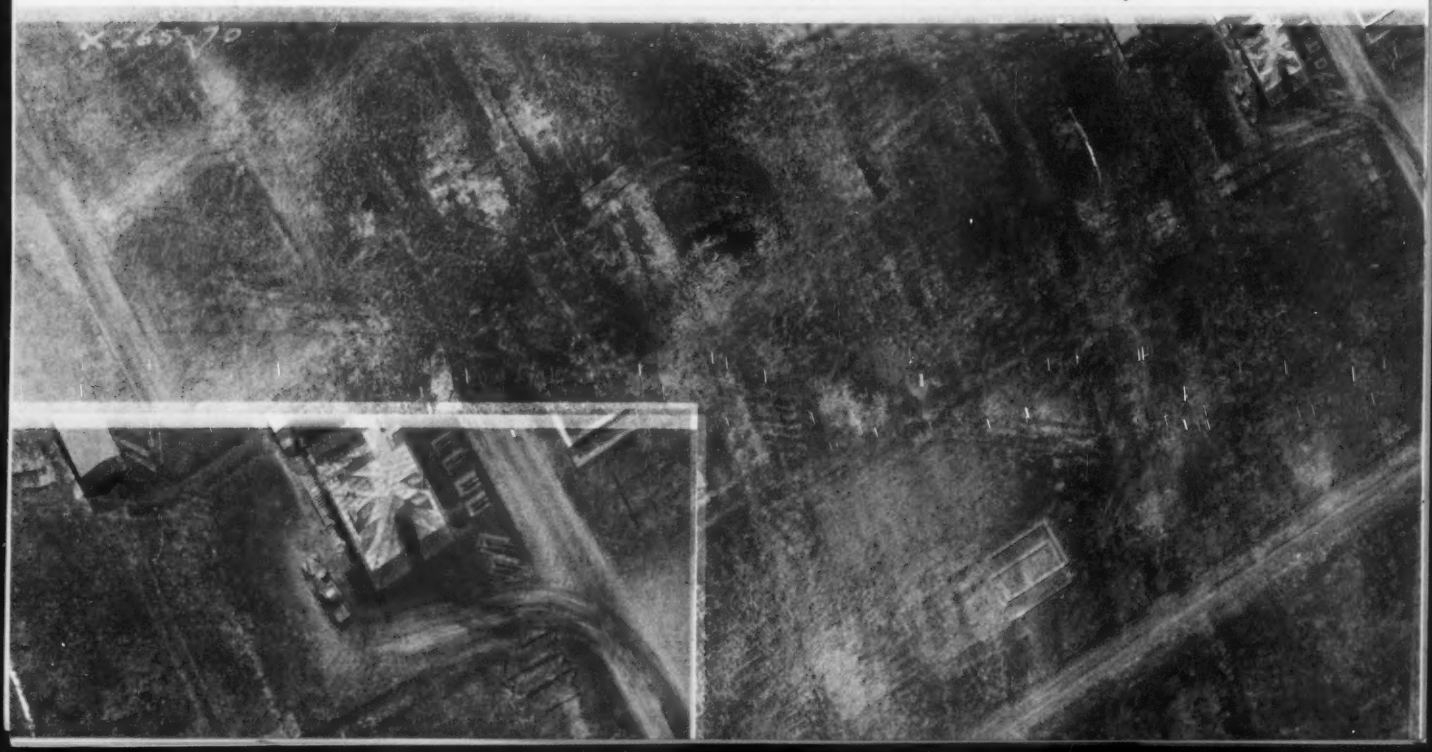
measuring the false parallax of the water surface. On the scale of the photos it will be an exact measure of the distance the water has moved between exposures. The time between exposures being known, a simple calculation gives the current velocity. It is of interest to note that the same principle can be applied to any moving object photographed twice from the same position. An example is the measurement of the deflection of a ship's plates in a seaway.

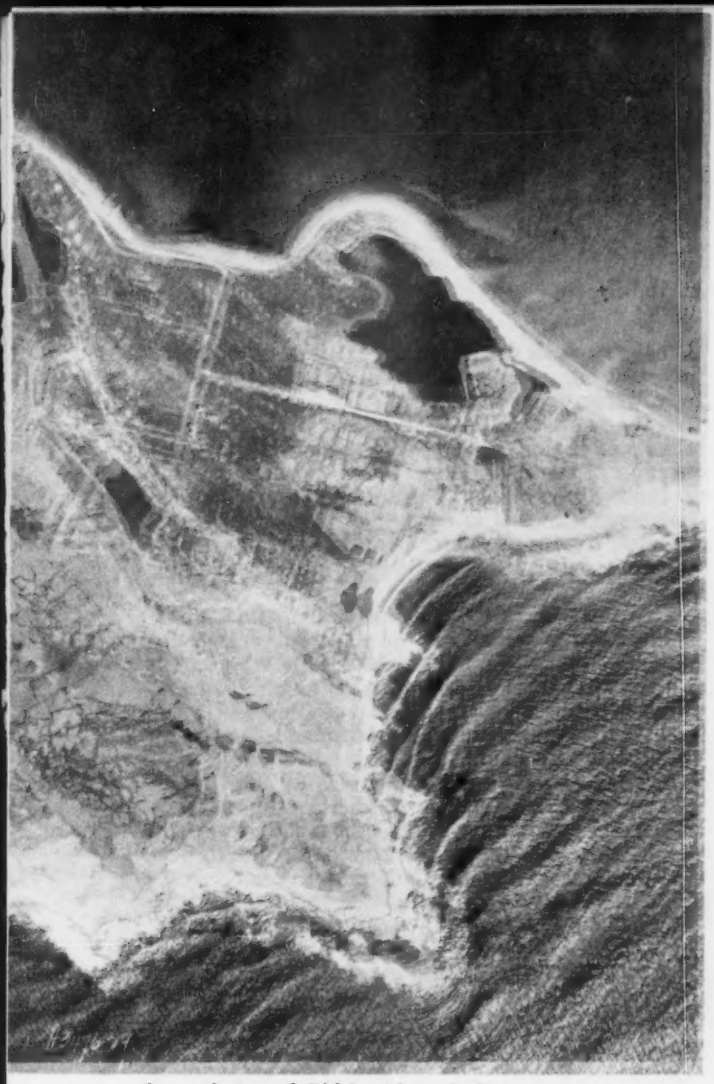
Archeological Applications

Archaeologists and historians in Europe have made considerable use of aerial photos in their studies of pre-historic and historic sites. A large number of historic sites, villages, camps, fields, villas, and forts have been located and mapped in England. The more famous of the Near and Middle East sites have been photographed, but the unsettled political state of these areas has hampered the ground exploitation of these methods. In the Americas a good start has been made, as shown in recent articles on desert markings in the American West and a city site in Peru.

Nova Scotia is particularly rich in historic sites, notably the Champlain Habitation at Lower Granville, where the first white settlers north of Mexico

Continuous strip photograph of Old Louisburg. Modern Museum in upper right hand corner and inset. Old anchors and guns show clearly. Old streets and foundations clearly apparent. Oblong is restoration begun on Nunnery.





General view of Old Louisburg before restoration was begun.

passed their first winter in the New World. By far the most significant historically is the old fortress city of Louisburg in Cape Breton Island. Built as a base and bastion against British sea power, it was captured twice and finally destroyed by the victors to prevent it ever fulfilling its purpose of preserving French power in North America. It is doubly important in that men from the New England States figured prominently in both sieges and captures. The first in 1745 was entirely a New England States show with an expedition under Sir William Pepperell capturing the place after a siege rendered absolute by a British Fleet. European politics gave it back to the French and English mismanagement left the New Englanders grumbling. The second capture in 1758 left them really blaspheming with the British Navy getting the Prize Money and the Americans being left to rot in garrison without pay. There can be no doubt that some of the seeds of the Revolution were sown here.

Historic Data Unearthed

In 1953 the R.C.A.F. obtained extensive photo coverage of the Louisburg site as an experiment, particularly with the continuous strip camera. The combination of low level large scale photography,

Old Louisburg, R.C.A.F. Infra-red, 1953
A—Garden Walk—Governor's Garden, 1759
B—Barrack Foundation—New England troops, 1759.

with high level infrared, has provided a wealth of data which is in process of being worked for the benefit of the historians. Some of these results are shown in Figures 4, 5, and 6. It is hoped that all the other historic sites in Nova Scotia will be covered in similar fashion in the near future.

This brings to a close our brief sketch of present day air-photo interpretation. There can be no doubt that the combination of modern aircraft and modern cameras has provided man with the greatest tool so far developed to give him rapidly a great mass of information about the world he lives on.

theory of the hydrogen bomb

by Dan Wadsworth, G.

The basic principle of the hydrogen or fusion bomb has been known for some time. As early as 1946, Hans Thirring, a Viennese physicist, published a book which discussed the theory of several types of hydrogen bombs.

The prime example of the fusion reaction is the sun which obtains its energy from nuclear reactions between hydrogen and carbon. However, temperatures of several million degrees are needed for nuclear fusion reactions to occur so that it was not until the detonation of the Uranium bomb that the high temperatures became possible on earth.

The thermonuclear chain reactions occur only at temperatures such as are found in the sun so that they cannot be controlled and, as far as is known today, can be used only as super explosives. For example, the d-d reaction involving the heavy isotope of hydrogen, deuterium, occurs only if the deuterons have kinetic energies of at least 100,000 electron volts which corresponds to temperatures of 7.7 million degrees Centigrade!

Although the actual design is a tough problem, a thermonuclear bomb consists basically of a Uranium bomb as detonator surrounded by a light element such as deuterium or tritium all enclosed in a suitable tamper material to keep the bomb from flying apart too fast.

When the Uranium bomb explodes billions and billions of fission atoms are released with average energies of about 100 Mev. These will impart some of their energy to the deuterium or whatever thermonuclear fuel is used. The temperature will continue to rise as the thermonuclear chain reaction spreads throughout the whole mass, forming a nuclear explosion.

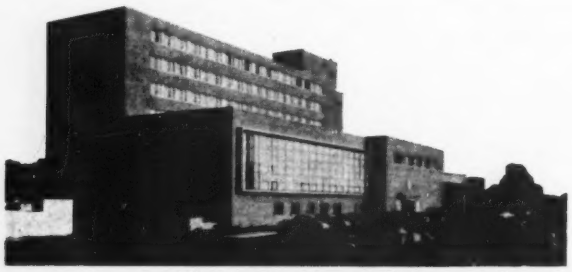
There are not very many reactions among the light elements which can be used for a thermonuclear bomb. The hydrogen-carbon reaction in the sun will not work because it takes billions of years to occur even in the core of the sun. If the high temperature is to be maintained the fusion reaction of the bomb must occur in millionths of a second. For this reason the faster deuterium-tritium reaction is better than the d-d reaction. Also reactions having a low ignition temperature with a maximum energy release are wanted. Several physicists have considered the possible reactions which may have been used in the last three H bomb tests. Among these is the recent "leak" by a N. Y. Times correspondent about a lithium-deuteride reaction. The following table includes the reactions most probably used in the H bomb tests.

Observed Reaction	Energy Release per Atom
$H^2+H^3=He^4+n$	17.6 Mev
$H^3+H^3=He^4+2n$	11.4
$Li^6+H^2=Be^7+n$	3.1
$Li^6+H^2=2He^4$	22.1
$Li^7+H^1=2He^4$	17.2
$Li^7+H^2=2He^4+n$	14.5

The reactions involving lithium are favored over those using the rare tritium since lithium is much cheaper and occurs naturally. Also lithium hydride or deuteride is a solid at room temperatures where as the deuterium or tritium must be in the form of heavy water or some other compound in which it is diluted by oxygen or carbon.

Data published by Rumbaugh in the Physical Review indicate that the 3.1 Mev reaction for lithium deuteride is favored (has a larger reaction cross section) over the higher energy reaction of 22.1 Mev. Also Rumbaugh showed that the last reaction in the table is favored over the preceding one.

The question is often asked whether an H bomb might set off the atmospheric hydrogen or the ocean if the bomb were big enough. Fortunately heavy hydrogen is very rare and none of the reactions involving ordinary hydrogen (except in the presence of lithium) proceed fast enough to be self sustaining.



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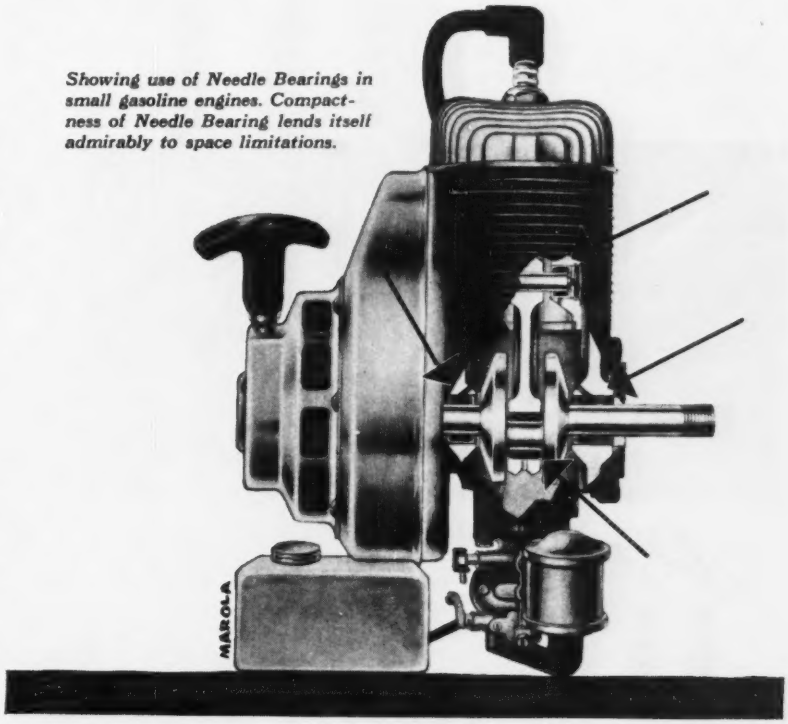

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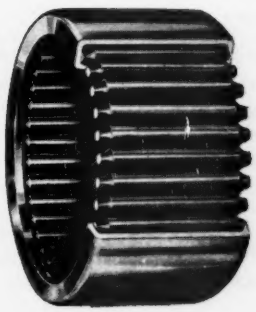

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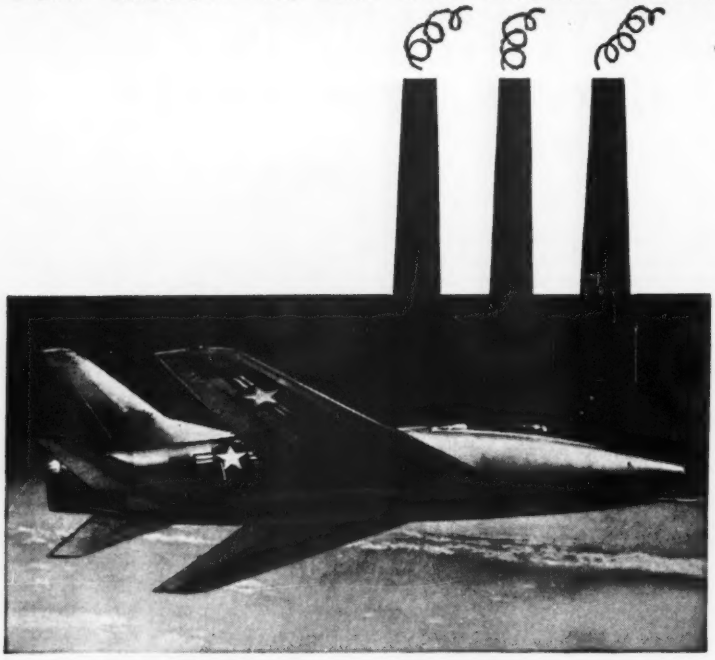

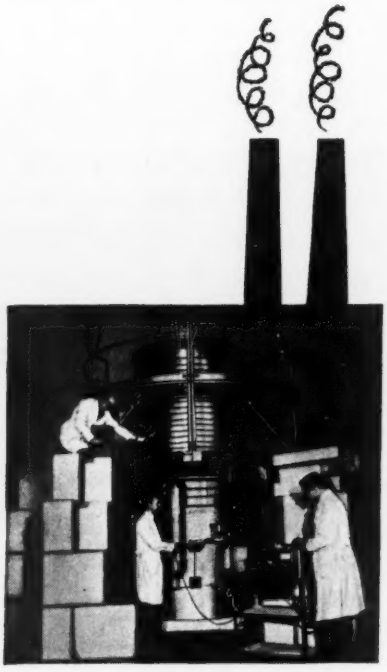

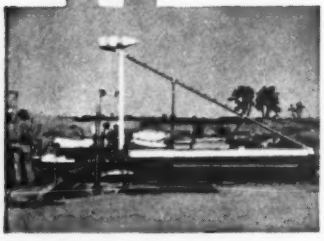

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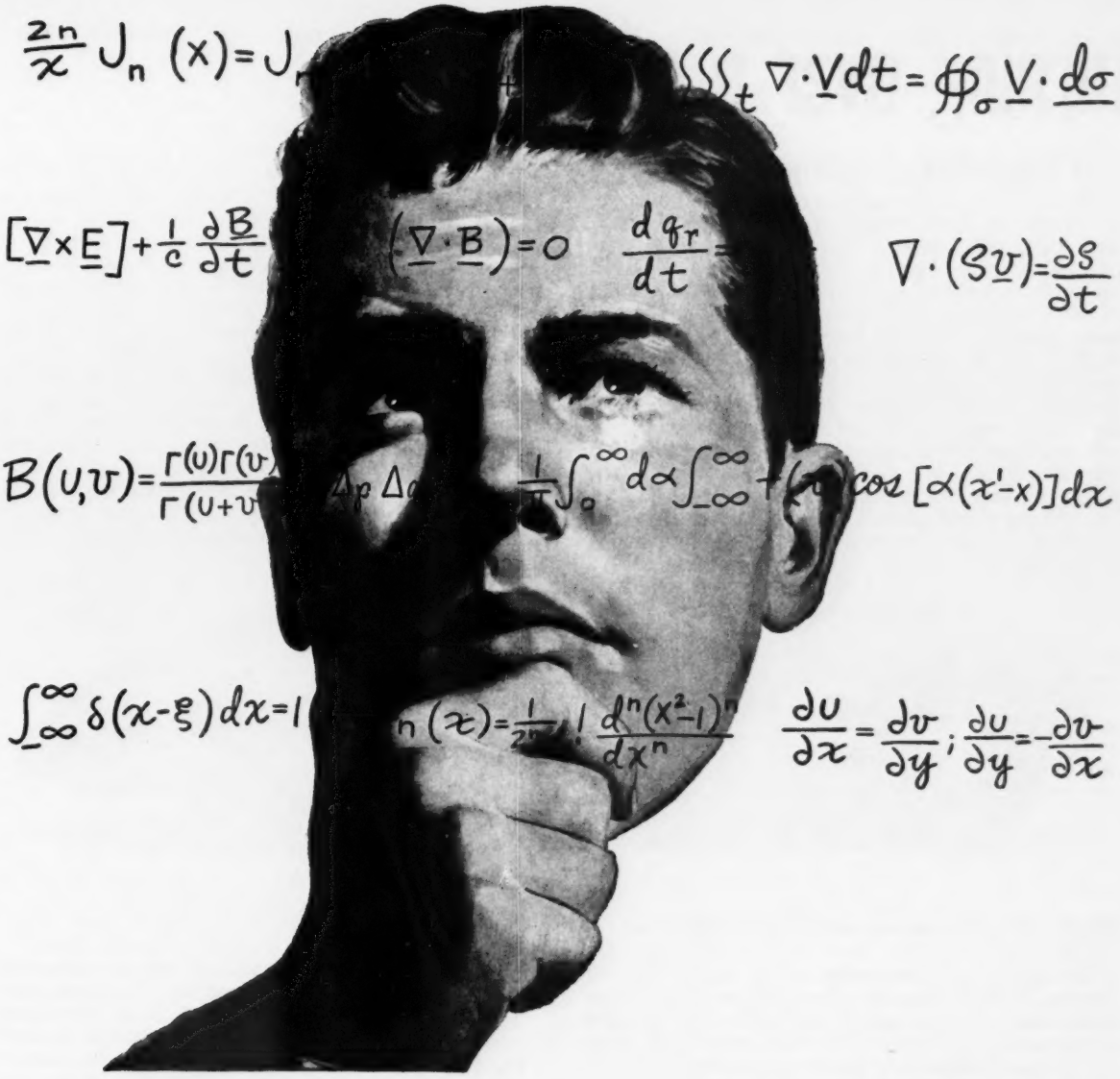
$\frac{2n}{x} J_n(x) = J$
$\iiint_t \nabla \cdot \underline{V} dt = \oiint_\sigma \underline{V} \cdot d\underline{\sigma}$
$[\nabla \times \underline{E}] + \frac{1}{c}\frac{\partial \underline{B}}{\partial t}$
$(\nabla \cdot \underline{B}) = 0$
$\frac{dq_r}{dt} =$
$\nabla \cdot (\rho \underline{v}) = \frac{\partial \rho}{\partial t}$
$B(u,v) = \frac{\Gamma(u)\Gamma(v)}{\Gamma(u+v)}$
$\frac{1}{\pi}\int_0^\infty d\alpha \int_{-\infty}^{\infty} \cos[\alpha(x'-x)]dx$
$\int_{-\infty}^{\infty} \delta(x-\xi)dx = 1$
$n(x) = \frac{1}{2^n n!}\frac{d^n(x^2-1)^n}{dx^n}$
$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}; \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$

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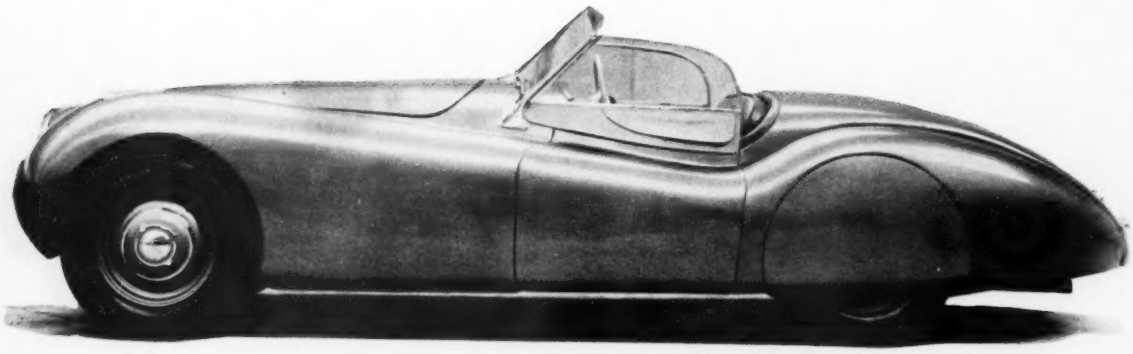
A Comparison of England's Newest and Fastest Sports Car

by Karl E. Ludvigsen '56



The XK 120 prototype had exceptionally clean lines.

We Americans are really a very lucky lot. We happen to have a lot of dollars which other countries seem to find especially desirable, and they are doing everything they can to take them away from us. It is regrettable in many ways that the British automobile industry has prostrated itself to the demands of the American motorist, since this change of emphasis has led to the demise of the wiry and lusty English sports cars that were, to me, the finest form of motoring. The latest imports are, it must be admitted, more appealing to a wider segment of the American public, and a real attempt has been made to build cars that can be driven by this public and still be fun to drive. These two criteria are difficult to satisfy simultaneously, and I would like to take up space here to discuss some of the cars that have been developed in Britain since the war to satisfy the American sporting urge.

"Some" in this article consists of the Jaguar XK 120, the Austin-Healey "Hundred", and the Triumph TR-2.

The now-famed Jaguar sports model was introduced at the London Motor Show in the Fall of 1948, and marked the return of the growing concern to the business of making very fast cars at an astonishingly low price, which they had achieved before the war with the rapid but somewhat unstable SS 100 models. The designers wanted to build a car with universally appealing lines, with as good a ride as was commensurate with decent road holding, and with an engine that would lend itself to the extraction of very high power while remaining reliable and reasonable to produce and service. This was to be done within the price frame of a thousand pounds.

Donald Healey had made a number of visits to the United States prior to the inception of the Austin-Healey, and he had come to the conclusion that the right car for the American market would be one with a high torque-to-weight ratio, to bring top gear and stop light performance into line with that of the domestic road machine. The car was to use components that were in quantity manufacture in England, to reduce the cost and improve servicing prospects. Such enthusiasm was evident at the car's introduction at the 1952 Motor Show, that the Austin concern, whose components had been employed, took over the complete manufacture of the car, thus rounding out their comprehensive automotive line.

The target set by Sir John Black for the engineers of the Standard Motor Co. in the summer of 1952 was an exacting one. He wanted a traditionally-lined sports car with a speed of over 90 miles per hour and selling for about five hundred pounds. This necessitated the use of Standard and Triumph parts as well as very

straightforward body design to reduce tooling costs. Three prototypes were constructed for the 1952 London Show, after which development started in earnest, with Ken Richardson, formerly of E.R.A. and B.R.M., in charge of testing. As a result of thousands of miles on the test track at Lindley gross alterations were made in chassis layout and the design was brought into shape for quantity production.

Of these three modern sports cars, the Jaguar has by far the most interesting and advanced power plant. To obtain high power with the simplest possible design, a twin overhead camshaft head was designed around Harry Weslake patents, with the angle of the intake ports designed to give maximum turbulence in the hemispherical combustion chamber. The valves, operating at an included angle of 70 degrees and seating in austenitic cast-iron inserts, are actuated through piston-type tappets with clearance adjustment by shims. The camshafts are driven by silent chain with a spring-blade tensioner, and with a clever arrangement for retaining the camshaft sprockets in place while the head is being removed so as not to disturb the valve timing. The 3,442 cubic centimeter engine has a stroke of 106 millimeters, which at the maximum r.p.m. of 5,000 corresponds to a mean speed of 3,940 feet per minute for each of the six pistons. Reliability is maintained at this high figure by the use of a forged crankshaft with seven main bearings of 2.75 inches diameter and big-end bearings of 2.086 inches. This engine, in stock form with two S.U. side draft carburetors develops 160 horsepower. In modified form (XK 120M) it puts out 180 plus horsepower, and in competition tune with three twin-choke Weber carburetors it has given upwards of 220 horsepower, which is equal to 1.05 horsepower per cubic inch.

The four cylinder Austin A90 engine proved to meet Donald Healey's demands well, as it gives 140 lb. ft. of torque at 2500 r.p.m. This good lugging power derives from a stroke of 111.1 mm. in an engine of 2,660 c.c. Once again Weslake and Co. had a hand in the design of the combustion chamber, but this engine is of more normal specification, with overhead valves in line operated by push rods from a camshaft mounted low in the block. Aspiration is through two side-draft S.U. carburetors, and the cleaning up of the exhaust has constituted the only alteration from the standard A90 unit, which produces 90 horsepower at 4,000 r.p.m., equal to about 3,000 feet per minute piston speed. A "Le Mans" modification kit is available which will raise the output to slightly over 100 b.h.p. The standard "Hundred" camshaft provides 230 degrees of opening for both valves, with intake opening five degrees before and exhaust closing ten degrees after top dead center.

In contrast to the preceding example, Triumph's engineers spent considerable time in converting the Standard Vanguard engine into a suitable sports prime mover. The output was increased from 76 b.h.p. at 4,500 r.p.m. to 90 b.h.p. at 4,800 r.p.m. The four cylinders have a bore and stroke of 83 mm. and 92 mm. respectively, which comes closer to the modern concept of "square" engines, and provides a peak piston speed of 2,850 feet per minute.

The three makers are united in their use of single dry plate clutches of Borg and Beck manufacture, the Austin and Jaguar using a ten-inch diameter model, and nine inches sufficing for the Triumph.

The variety of approaches to the transmission problem, however, is interesting. Jaguar Cars simply clamped the gearbox from the old Mark V model onto the new engine. This unit gives ratios of 1:1, 1.37:1, 1.99:1, and 3.38:1, the first three of which are synchronized. Austin and Triumph, on the other hand, made several modifications. The former took the expedient of locking out the low gear of the A90 gearbox, thus giving three synchronized speeds of 1:1, 1.42:1, and 2.25:1. A Laycock-de Normanville overdrive is standard equipment, and provides a ratio of 0.76:1 usable in the top two gears. Triumph succeeded in the difficult task of building another speed into the three-speed Vanguard gearbox while using the same casting and making it on the same machine tools. Its top three speeds are synchronized, and it offers ratios of 1:1, 1.325:1, 2.00:1, and 3.38:1. The Laycock overdrive is available as an optional extra, in which case it operates only in high gear and gives an additional ratio of 0.82:1.

All three cars use the open Hotchkiss drive system with a live rear axle attached through semi-elliptic springs mounted outside the frame longerons. The two smaller cars use an underslung construction at the rear, however, while the Jaguar has a kick up in the frame side members to accommodate the greater amplitude of its wheel movements. Jaguar and Triumph use the hypoid gear pattern, and Austin retains the spiral bevel system. Rear end ratios available are: for the Jaguar: 3.64:1 or 3.27:1; for the Austin: 4.125:1, and for the Triumph: 3.7:1.

These three constructors agree for the most part on frame construction. All have found channel steel best suited to mass production, and have placed cruciform center members in their designs. The Austin places its side members closer together than the others, and thus must support the body by additional cowl bracing.

Again, there is general similarity in the pattern of the front suspension. All the cars use an unequal-length wishbone system intended to strike a compromise between variations in track and in camber, but they differ greatly in detail. The Jaguar system is the most interesting, in that it uses ball joints as combined steering and suspension pivots (introduced by Jaguar in October, 1948), and uses 52 inch long torsion bars of silico-manganese steel for the suspension medium. These latter are splined to the lower wishbone at the front and to frame anchorages at the rear. The design incorporates an anti-roll bar and tubular shock absorbers, both of which are attached to the lower wishbones. The Triumph and Austin both have conventional king pins and coil springs, but the former uses tubular dampers and dispenses with an anti-roll bar, while the latter has hydraulic dampers integral with the upper suspension arm and has a connecting torsion bar at the front.

Three-piece track rods are used on all three cars, with the Burman cam-and-lever steering box on the Austin and Triumph, and a re-circu-

lating ball type on the Jaguar. The latter has much the lowest-geared steering of the trio, with three and one-quarter turns from lock to lock. The Austin and Triumph are two and one-half and two and one-quarter turns respectively.

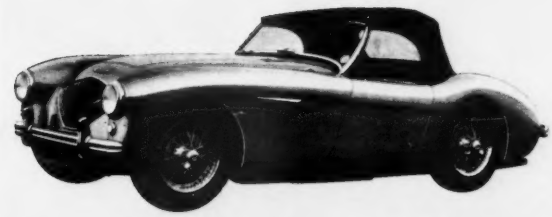
Hydraulic brakes with two leading shoe construction on the front are common to these makes, and the Jaguar leads the square inch of lining parade with 208. The two smaller cars have about 150 square inches apiece, and as a result of its light weight the Triumph has the highest number of square inches per ton, the value being 167.

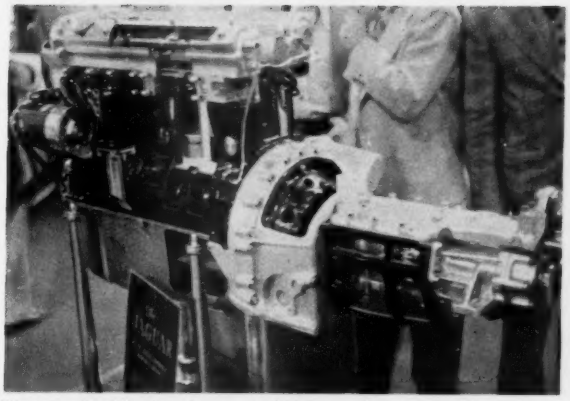
Bodywork is in general in the same idiom, which Jaguar can claim to have originated. The pioneers, however, have much the least practical arrangement of body panels, while the latest, the TR2, is to be commended for a serviceable and repairable structure. The Austin occupies a place midway between these extremes. All three have about the same luggage capacity, but the spare wheel of the Austin is placed forward of any baggage, while that on the other two cars is located below the trunk in an accessible position. Instrumentation is identically complete, except that Austins have seen fit to omit the ammeter.

Driving a Jaguar is a confusing experience. You approach the car with awe. You say to yourself, "Now here is a real machine. When I have driven this I will be another and better man." But this is not so. When you have done you feel that you have learned or gained nothing. The Jaguar accomplishes this by being as innocuous and characterless in behaviour as an American sedan. The amount of usable room in the XK 120 offers no improvement over the M.G. The pedals can be sorted out fairly easily, but the long-legged driver finds the steering wheel fouling his thighs unless it is pulled uncomfortably far back. Most dealers are able to move the seats some three inches farther back than standard if required. The Jaguar is a large car, and the driver finds an impressive vista of hood and fenders spreading out before him. With the engine appropriately warmed up, the performance through the gears is perhaps the most inspiring thing about the car. Municipal speed limits can comfortably be exceeded in first; zero to sixty tests can be made in two gears; in third you can pass Fords traveling flat out, and in top you can pass Chryslers most of the time. The gearbox is not rapid, and has a long travel between first and second. Top to third is handy, but not so good as the other two cars tested. The rapid engagement of the clutch from a standing start produces a certain amount of agitation of the rear end, and one has the feeling of being seated in a large mass with a great deal of force being applied to it. The brakes are light and effective but do not give an impression of lasting stamina, especially after several stops from the vicinity of ninety per. Steering is light, and the large number of turns is in part compensated for by the remarkably small turning circle. Handling is still of a casual nature, however, and I can state that I have had just as much fun and surely more excitement in hurling an Oldsmobile 98 around a corner.

It is odd, but, I think, true, that the innocuous way in which the Jaguar delivers its power has caused it more trouble in service and repairs than any other factor. Owners experience this smoothness, and, taking reliability for granted, drive the car in top gear all day without warming it up, or, alternatively, drive flat out across country without giving due consideration to proper lubrication. Needless to say, the Jaguar's highly tuned and sensitive engine will not stand up to this for long. An understanding enthusiast is necessary to get the best out of the car, but unfortunately the standard XK 120 holds little appeal for this class of buyer. I know of a dealer who, in desperation, has taken to leaving the governors on new Jaguars for as much as 8,000 miles in order to insure proper break-in treatment. This car fits best in the hands of a one-eyed enthusiast who wants to travel quickly and who will accordingly spare no expense in maintaining his machine. Those who want a sporty roadster to drive around town (a class much catered to by Jaguar) without worries of shifting gears or expensive machinery would do well to buy an Austin-Healey.

The engine characteristics and drive train of the Austin make it a car admirably suited to American driving and traffic conditions. The electrically-operated overdrive contributes greatly to this state of affairs, and if it continues to operate as positively and instantaneously as it does now it will be hard to beat. With the dash switch in "normal" position the car is in direct drive at all times. The shift from direct to overdrive takes place without any accelerator movement, and with the switch in "overdrive" position it occurs at 40 miles per hour. At any speed below 30 miles per hour a slight pressure on the pedal will engage direct drive, and there is no way of avoiding this. At speeds above 40 the switch can be used directly to change from overdrive to direct. This is all very handy, once you have doped it out, and it is also possible to wire the switch so that it is a direct control at all speeds. The shifting pattern is a spread-out affair, as one might expect from the modifications that were made, and the shift itself is positive but not smooth, with synchromesh low a real convenience. The arrangement is such, however, that the driver need not touch the gear lever except in very slow traffic work. The engine is capable of pulling efficiently from very low speeds, and is aided by the numerically high ratio of direct third gear. The acceleration through gears is close to that of the Jaguar, although the gear arrangement does not provide a good selection of ratios from a standing start. Steering is much quicker than the XK, though not so quick as the TR2. It is commendably light, but as a result also gives quite a bit of road reaction in the steering wheel. It is necessary to hold the wheel lightly to avoid excessive tiring of the forearms over bumpy roads. The Austin driving position gives the best protection from the wind in open trim of the three cars driven. The top of the door is almost at the shoulder level of the driver, who must resign himself to keeping his elbow inside the car. On the latest version only the driver's seat is adjustable, which brings to mind one of my chief complaints with late model British roadsters. They have, in many cases, an almost derisive re-





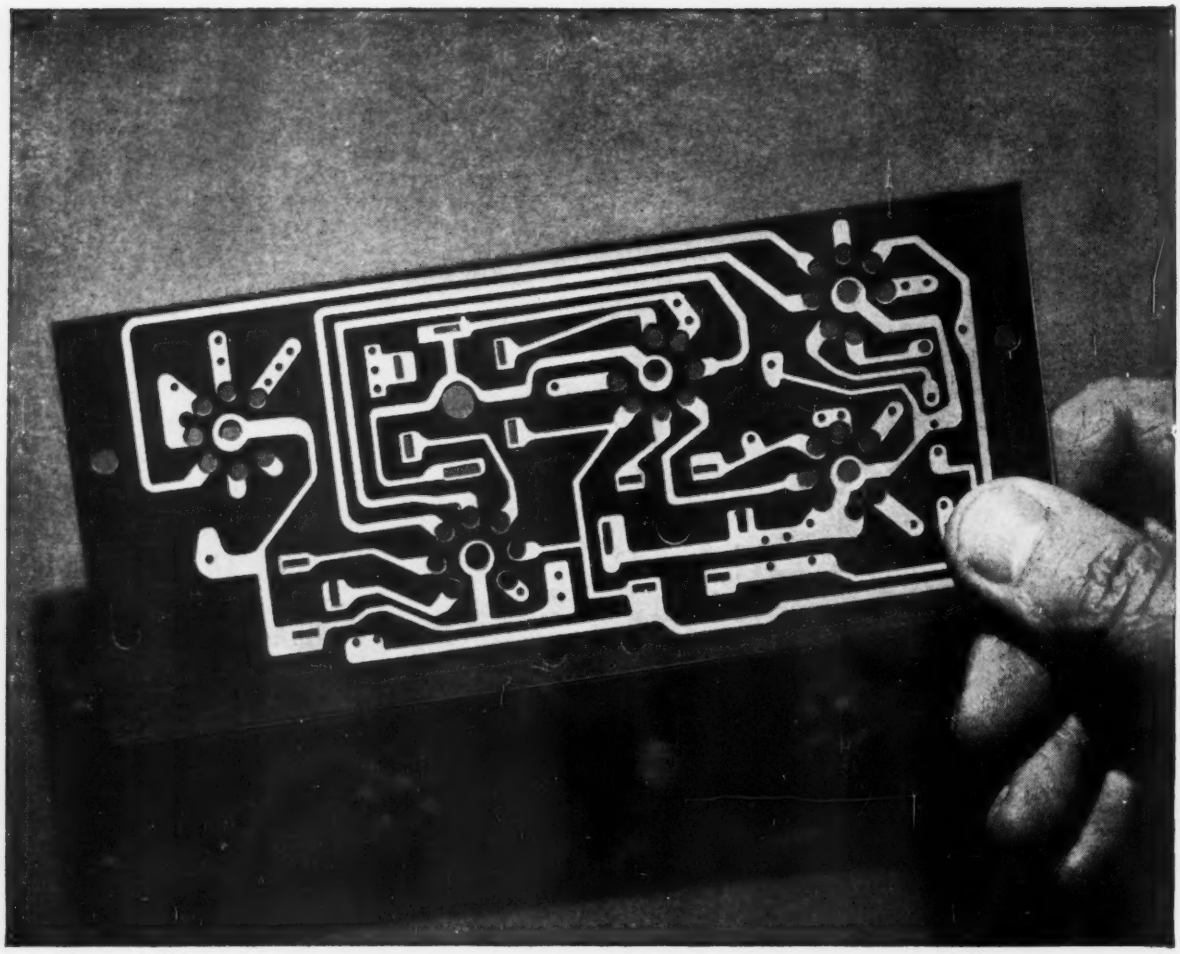
The Austin-Healey top provides excellent weather protection.

Many racing practices have been used in the design of the Jaquar engine.

gard for the comfort of the passenger. The prime example of this is the false footboard in the TD and TF M.G.s, which, if removed, gives around four or five inches more legroom. The only reasons that I can see for this clever device are a) to torture the passenger and b) to smuggle jewels, small Mexicans, etc. over a handy border. For the driver of the Austin-Healey the engineers have contrived to provide two inches more legroom than exists in the much larger Jaguar, but the passenger, if at all tall, suffers greatly in his non-adjustable enclosure. The recommended tire pressures for the Healey are 20 pounds front and 24 pounds rear. We increased these to 23 front and 26 rear for the purposes of our test, a change which we did not regard as overly significant. Under these conditions the Austin rides almost as well as an M.G. TD, but shows a greater sensitivity to road irregularities such as dividing strips in concrete roads. When cornering the car remains quite flat, and the rear end shows a propensity to hop about on a bumpy bend. It is my opinion that the designers have not been overly successful in an attempt to compromise between ride and cornering stiffness, the car absorbing large bumps well but being irritatingly sensitive to small ones. This, of course, is of no concern on a macadam parkway, to which the Austin is well suited. This car, on the whole, is not one that I would choose for competition. Its engine size pits it against the toughest in the business, and those 2.6 liters, while full of torque, do not respond well to further tuning. Moreover, the gearbox is much better suited to fast touring than to racing. The Austin-Healey is perfect for the American buying his first sports car, who wants (or should want) a machine on which he can make mistakes without hurting things. For real fun, on the other hand, and competitive performance at a reasonable price, one would go the world 'round without surpassing the Triumph TR2.

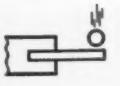
The Triumph driving position is one of my favorites. One sits fairly high, in a seat with good side support though not with the cushioning of the other more expensive cars. The seat is adjustable over a very large distance, and foot and legroom is by far the best of the three cars. The door is cut away at just the right angle to allow unobstructed arm movements. The steering itself has the same ratio as the M.G. TD, and is not so light as the Austin, there being a feel of internal friction rather than of excessive castor action. There is no road reaction, however, and the wheel is placed well away from the driver. The general ride characteristics are good, with the Triumph absorbing small irregularities but reacting strongly to grade crossings at speed. In spite of this there is little roll on corners, and the short wheelbase gives the car great agility while detracting slightly from its stability at speeds near its maximum. The transmission is close to the M.G. gearbox in excellence of shifting, with a small shift pattern and direct control, and in this respect is the best of these three cars. Second and third gears are more audible than is customary these days, however, although not disturbingly so. Acceleration through these gears is exhilarating, to say the least, and the exhaust has a spirited snarl, as opposed to the sophisticated purr of the Jaguar and the throaty yawp of the Austin. The regular top gear without overdrive is fine for turnpike cruising, and the overdrive might be useful for desert commuting. One very impressive feature of the Triumph is its excellent underhood accessibility. The opening is much wider than either the Jaguar or Austin, and all maintenance points, including the master cylinder, are readily reached. In general, the Triumph is a nimble, agile machine, with many features that would appeal to the owner who does his own maintenance. The engine is powered to produce a competitive car in the two-liter class, and a multitude of racing accessories are available from the factory for the car. It's an excellent car for the novice enthusiast who wants high speed with safety at low cost.

All parts needed to convert the Triumph to high-speed trim are available from the factory.



Pattern of things to come

IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS

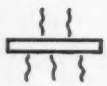


1. Impact strength. Synthane stands up in mechanical applications where jolts, jars and light shock loads are common. It does not splinter or break readily; will not delaminate.

2. Tensile strength. Synthane is strong in tension and compression.

3. Light weight. Synthane has approximately half the weight of aluminum.

4. Flexural strength. Synthane is suitable for jobs where deflexion, torsion and vibration are present. It has excellent fatigue resistance.



5. Stable Over Wide Temperature Range. Synthane is thermosetting; does not flow as temperature rises, has a low coefficient of thermal expansion.

Here is one of the brightest ideas in electronics—and one of the materials which helped make it possible. The idea is the printed circuit; the material is a laminated plastic called *Synthane*.

For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

Then someone came up with the idea of *printing* the circuit with an acid-resisting ink on foil bonded to a base—and etching away the metal not needed. It would be quick, easy and error-proof—if the right base material could be found.

Among many tested, *Synthane* was one sheet material selected. Synthane has the necessary strength, low moisture absorption, is an excellent insulator and can be punched easily. It bonds securely to metal foil and withstands the etching acid used to remove the excess metal.

The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

Synthane laminated plastics are available in a variety of grades and colors—in sheets, rods, tubes, and fabricated parts. You are invited to write for information to Synthane Corporation, 13 River Road, Oaks, Pa.

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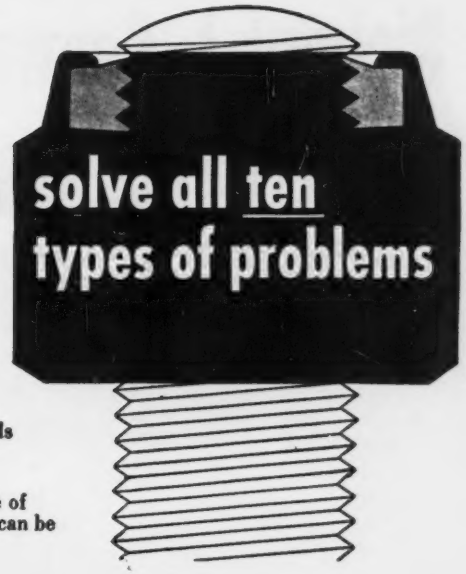
elastic stop nuts solve all ten types of problems



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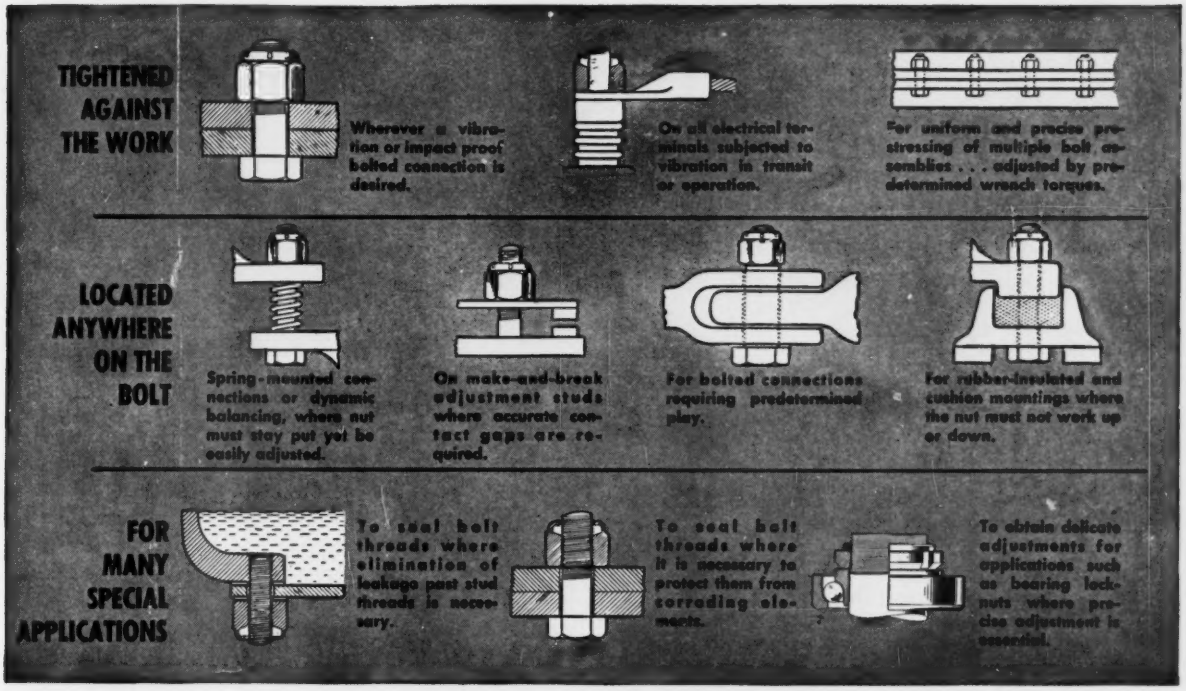
ELASTIC STOP nuts stay tight, right where you put them, in spite of vibration and stress reversals. Yet they are not jammed in place, and can be removed with a wrench and reused many times.

For further information on ESNA self-locking fasteners, mail the coupon below.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Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

RICHARD CONWAY checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

When you're thinking of a good job, think *high*—think *Worthington.*

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WORTHINGTON

The Sign of Value Around the World

½ RECORD REVIEW

by David L. Klepper, G.

This month I'd like to first mention two recent RCA recordings that appear to be exceptions to this company's normal domestic recording in their excellent sound. The first is LM 1750, containing Kodaly's Hary Janos Suite and Bartok's Divertimento for String Orchestra, both performed by the Minneapolis Symphony Orchestra, conducted by Antal Dorati. The same performance of the Bartok work was previously available on another RCA recording, coupled with Mozart's Symphony No. 31. Here the sound shows definite improvement; both sides of the newer record are worthy of comparison with Mercury's recordings of the same orchestra. Although I do not favor Dorati's performances in general, especially his readings of classical symphonies, his interpretation of the humorous, gusty, Hary Janos is all one could want; his Bartok performance deserves comparison with the also excellent one of Tibor Serly on Bartok 905. RCA maintains its high standard for its surfaces here.

LM 1783 is a really welcome surprise. Here Lili Krauss enlivens the Mozart Piano Concerto KV 414, No. 12 in A, with such warm, sensitive playing that this concerto becomes newly appealing; it never impressed me so much in the past. She does equally well in the very fine Concerto K 456, No. 18 in B flat. Pierre Monteux conducts the Boston Symphony; after this pair of performances I'd like to hear more of Mr. Monteux on Mozart. Lili Krauss' only competition on the 18th is herself, in a somewhat inferior recording, so this record will endure for some time as one of the three most valuable Mozart piano concerto recordings available.

On this recording RCA has used its new "ultradirectional" microphone with more success than before. The resonance of Symphony Hall remains present; the sound of both the orchestra and piano is most natural; and the entire recording is a close approximation of a WGBH live broadcast, very highly praiseworthy. Surfaces, unfortunately are not fine, just fair.

From Mr. Irving Kolodin of the *Saturday Review* we learn that Allegro (Record Corporation of America) released the entire Wagner Ring cycle by taping the AM broadcasts of the Beyreuth Festival performances. He advises us to beware the missing music at the point where the home recorder's 7 inch reels ran out. This complete lack of ethics on the part of this company causes me to suspect the origin of other "live performance" releases of this company.

Regarding the Scherchen performance of Handel's *Messiah*, I'd like to point out that Sir Thomas Beecham will soon provide a new performance for American Columbia which may well rival his older one for RCA (via HMV) and have the advantages of modern sound. Sir Malcome Sargent, whose old performance on Columbia never appealed to me, will make a new recording for British Columbia, possibly available to us on Angel; London will probably further complicate matters by releasing the recording conducted by Sir Adrian Boult already recorded for English Decca. I'd suggest you wait until these performances are available before deciding; also investigate the performance conducted by Sir Ernest MacMillon, very fine in the traditional manner but handicapped by less effective soloists, a good bargain on RCA's Bluebird series.

Regardless of the other performances, Scherchen's, as very well recorded by Westminster, will probably find a permanent place in my collection. On the basis of two listenings, without score and interrupted by phone calls, visitors, etc., I've discovered new beauties in the work; often where he is most controversial he seems most correct to me. His Amen is slower than anyone else dares take it, but it sounds right.

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peace, 1954

by Lionel Fray '57

On a peaceful Sunday morning in December 1941, a few hundred Japanese airplanes executed one of the most successful sneak attacks ever perpetrated. This attack dealt the United States a blow which took over a year of intensive industrial effort, and thousands of American lives to neutralize.

A similar occurrence, in this age of nuclear fission, would be conclusive in its finality: there would be no opportunity to effect a comeback. The war begun on a Sunday morning would be over that evening and the price paid for this display of atomic fireworks would be about half the human race.

Until a few years ago, when this country was the sole possessor of the atom bomb, the problem of defense was simple; no one would be willing to face the retribution of an attack on us. Photographs of Hiroshima and Nagasaki would convince the worst skeptic. The starting gun of the present atomic arms race was fired, however, when President Truman announced to the world that a thermonuclear explosion had been observed in the Soviet Union. We had to modify our defense strategy and content ourselves with the idea that we had a head start in the contest, in the form of bigger and better bombs. The point had been reached, all too quickly, where both countries had enough potential destructive ability to destroy the other. Our defense policy was antiquated; we needed a better solution to the problem.

The only solution is a means of effecting immunity from attack. It transgresses the boundaries of the military because it involves the application of modern science, which alone can offer any hope. Radar, "homing" rockets, electronic computers, all of which have been developed to the point where they can be applied to this problem. The continent must be surrounded by rings of radar warning systems and numerous counter-attack airplane bases. The time element is extremely important. Five minutes could easily mean the difference between survival and annihilation.

As you can imagine, such a system would be economically very expensive. It is the ounce of prevention, however, that may prove to be the means of deterring a would-be aggressor. He would be faced with the sobering prospect of our retribution if his first shot missed.

In 1950, Congress appropriated funds for the express purpose of investigating ways and means for producing a satisfactory protective network. It was soon apparent that the job was too big for the Air Force alone to handle—the other services soon came into the project with their own budgets and personnel. The original research and industrial know-how could best be put to use on a civilian basis, and accordingly a center of operations which would include a considerable number of trained scientists and sufficient experimental equipment was needed. MIT was chosen because of its managerial experience in dealing with the government during the war, and its extensive radiation laboratory facilities. The Lincoln project came into being.

Its organization is complex as it includes elements of the national government and the three military services in its administration. Money was provided for construction of extensive facilities off campus but because of the urgency of the matter, the project was temporarily installed in Building 20, which had already seen several years of service as a research center. It is a typical example of the architecture that was characteristic of the government buildings hastily constructed during the war. Long an eyesore in the MIT community, it is slated to terminate its career June 1, but it has fulfilled its function. Lincoln has been moving gradually to its permanent location outside of Lexington in a pleasant suburban atmosphere. Rows of modern buildings, each properly adorned with its share of rotating radar antennae, and an adjoining airport, all hum with feverish activity. The basic ideas were formulated during the first year of the venture, although emphasis was placed on a broad, flexible development capable of changing its scope to keep up with any unexpected developments in the field. Production was started during this past year and is now well underway. Construction of the project itself, however, has not ceased. It is still expanding rapidly.

The problem of security is another headache which must constantly be considered. The project is amply guarded and its personnel, down to the last janitor, have all been checked by the F.B.I. Any visitor will testify to the thoroughness of the constant checking and watchfulness. Justifiably, no economics were attempted in this direction.

MIT has a cost contract with the government which means that it cannot possibly make any money on the deal, although it can conceivably lose quite a bit by an error in procurement, for instance. The upper echelon of the staff, headed by Dr. A. G. Hill, director, are mostly MIT men. Several professors have been borrowed on a full-time basis as consultants during this period of emergency and this has created a personnel problem in the faculty, especially in the Physics Department.

MIT is primarily an educational institution and as such, has no desire to participate in research in other than purely academic fields. The security regulations make it impossible for Lincoln to be used by graduate students for their thesis, and the drain on the faculty, especially in these times of an acute shortage of instructors, has been considerable. Considerable credit is due the Institute for the very fine way in which Lincoln has been handled. Few students realized the scope of the enterprise and the effect on campus life has been almost negligible.

The United States owes a great debt to institutions like MIT who are willing and able to don the somber garments of war when required. The service they have rendered in this capacity in the past has been truly remarkable. As a great scientific center of learning, however, their greatest contribution by far can be along peaceful lines to help mankind live a better, happier, and more productive existence.

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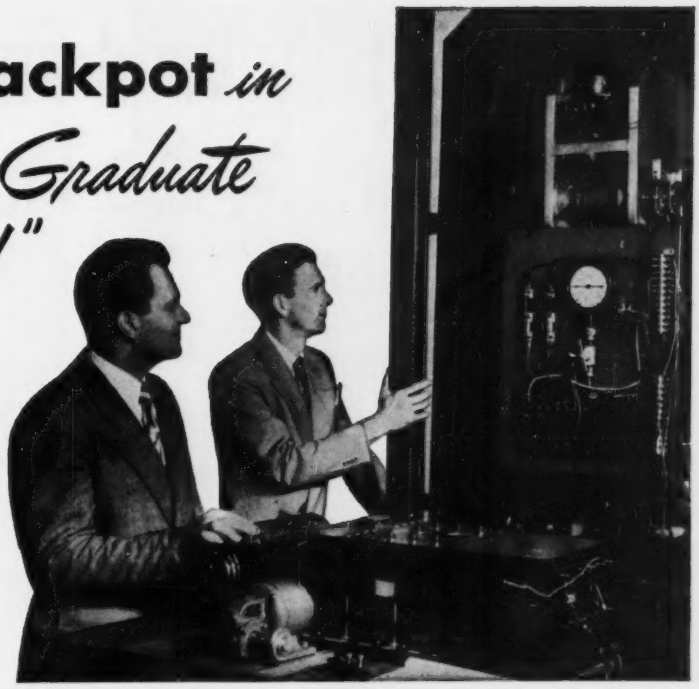

say N. W. MORELLI

Oregon State College, B.S.,M.E.—1950

and

E. R. PERRY

Texas A. & M., B.S.,E.E.—1950

WHILE taking the course, two engineers developed a revolutionary new circuit breaker mechanism.

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"Circuit breakers soon became an obsession with us, and we got the idea of designing a hydraulic operator and triggering mechanism for these breakers. Most operators for big breakers are pneumatic.

"Unsuccessful attempts had been made in the past by all circuit breaker manufacturers to build hydraulic operators. The important thing is that no one at Allis-Chalmers said, 'Don't try it—it won't work.' "

Start New Era

"To make a long story short, our study of the problem led us to the hydraulic accumulator and high speed valves being used by the aircraft industry. These had not been available when earlier attempts were made to build a hydraulic operator. With these highly developed devices to work with, we were able to build an operator that combined the best features of pneumatic and hydraulic operation. We call it the *Pneu-draulic* operator. Engineers are saying it starts a new era in circuit breaker actuation.

"This fact is important to us, but it is even more important to know that Allis-Chalmers Graduate Training Course is full of opportunity . . . and as we found out, there's opportunity right from the start."

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For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

C-5675

antigone, billy budd and the caine mutiny: the individual and society

by Warren Bennis

Faculty, Dept. of Economics and Social Science

Scene: Oak paneled office in the Friendly Ball Bearing Company Building. Bill Friendly, Jr., the young, dynamic president has called his staff together for their daily session of *ego-setting*, a new practice which Friendly learned at his last workshop in social physics. Ego-setting consists of a simple paradigm for getting the real *I* or ego above board, so to speak, where it can be seen by all. This has replaced the old method of *catharsis*, a primitive development which was concerned only with getting the feelings above board.

Friendly: (To staff, smiling) Before we begin with our ego-setting exercises, I'd like first to get our daily Cohesive Report. Jim?

Jim: (Director of Cohesion.) As of last night at 5:00 P.M. the cohesion co-efficient was 97.5%. The drop off from the night before was undoubtedly due to Peer Group number 6.

Friendly: (Smiling) You mean?

Jim: Yeah, one of the worker's cars broke down, which upset the car pool cohesion ratio, meaning that several workers from Peer Group number 6 had to be split up among other groups. We're doing everything we can to get things squared away, and the car pool teams back on regular schedule.

Friendly: (Smiling) Well, that takes care of 2%. How about the .5%?

Jim: Well, our old problem. Charlie, leader of Peer Group number 7 found one of his men eating alone yesterday. This is the second time he caught him in this nefarious position, and one more warning, and I'm afraid—

Friendly: You mean?

Jim: Well—we hate to let him go now. You know all the work we've done to rig the group so that each role needed by a group was played by a group member. After his Rorschach, we were convinced that this man was a perfect *energizer* but he just doesn't seem to be working out.

Friendly: (Smiling) Well, this is serious; that is, we've got to understand this thing in its deepest context and really get in—*I mean in*—this man's frame of reference. Bob, what are your feelings, sentiments, and values about all this?

Bob: (Director of Interaction) Well, Bill, we've done about all we could with this peer group. Our slogan, "An interacted worker is a happy worker" is on every peer group eating table. And we've placed Peer Group number 7 in the middle of the plant so that they practically have to interact all over the place walking to their team workplace. To tell you the truth, this maverick is a surprise. When we hired him, he was interacting all right. We took him through our normal interviewing and hiring procedure. He met and was interviewed by 64 of us, and he certainly didn't seem anxious about that.

Friendly: (Smiling to staff psychoanalyst) Greg, what's his syndrome?

Greg: It's not a simple case. This person apparently has a submission complex, an anxiety neurosis which manifests itself by the afflicted individual having fantasies about desiring to be alone. From what we know today, the return to womb, or peer group, is man's salvation. However, these infantile regressions do come up and interfere with the man's work processes.

Friendly: (Smiling to Director of Morale) Well, Pete, have we done all we can?

Pete: I'll tell you, Bill. This man is a trouble maker. He's pulled down the morale index from the minute he put his foot in the plant. Do you know that two times in the past three months he's questioned his own foreman about an order?

Friendly: (Smiling) You mean?

CURTAIN

The prologue, however satirical and ludicrous, lays a heavy hand on one of the most searching problems of our age: the social responsibility of the individual to society. This problem has persisted in one form or another in each era and each culture and perennially defies us. In fact, Culture—with a capital "C", is the long playing record of society, communicating to us the dilemma of the individual and authority. To be sure, this problem has long existed, but in a qualitatively different form. For the present day struggle pits Man against the Organization, while the conflicts of the past concerned Man against Nature.

Let us turn to three pieces of literature for a lightly-stepping historical view. The year is 429 B.C.; the play, Sophocles' *Antigone*. Creon, the King of Thebes, has decreed that Polynices not be given formal funeral rites for he died invading his native state at the head of an alien army, the greatest crime a citizen could commit. His punishment: that his body be left uncovered and untended, a temptation to birds and dogs of prey —a fate worse than death itself and regarded as a peculiar horror by the Greeks. Antigone, the sister of the unfortunate warrior, is determined to give her brother a respectable funeral, "to heap earth upon my brother, whom I love." In vain, she begs her sister, Ismene, to help. Against great odds in favor of discovery, and in view of the death penalty, Antigone buries her brother. Creon orders her to be entombed in a cave until death. Chalk up number one for authority.

In Herman Melville's allegory, *Billy Budd*, Good and Evil battle, monitored by a fatherly, reasonable naval captain representing authority. Billy Budd is a young, impressed seaman aboard the H.M.S. Indomitable. The year is 1799, the British are fighting the French, and there had been three mutinies aboard British ships-of-war in recent months. Billy Budd becomes a magic charm to the sailors. He is selfless, sensitive, and a good sailor. Everybody aboard makes a mascot of him—except the first mate, Claggart. For his own perverted reasons Claggart tries "to get Budd." Already Claggart has put men to death for slight offenses. After a long period of trying to incriminate Budd by false charges and by planted schemes, such as upsetting his bed before inspection, Claggart plays his trump card. He reports to Captain Ware that Budd has planned a mutiny. An incredulous Ware makes Claggart personally confront Budd with the charge. Claggart repeats his charge before Budd and the crew. Billy Budd, in response to the charge, falters in speech, stammers, and in a moment of violence, strikes out and hits Claggart. After falling and hitting his head on the ship's rail, Claggart dies. Captain Ware immediately sets up a rump session court consisting of the three ship officers and himself. In an eloquent speech, he points out to his wavering juniors that Budd's crime can be punishable only by death. He points out that the "good of the service and country are at stake." That, unfortunate though it may be ("as we all love Budd"), the morale of the crew would in the long run suffer if Budd were not punished under the mutiny laws of the majesty's navy. Budd hangs.

The Caine Mutiny by Herman Wouk is presently a best seller, a play assured of a long run on Broadway, and, shortly, a star-studded movie. It is a well told novel about a creschendo of emotions which erupts into a miniature mutiny aboard a mine sweeper in World War II. Captain Queeg is an incompetent and seriously neurotic skipper who, by the grace of God and a sterling executive officer, manages to escape serious damage throughout the war. Finally, a situation arises where either the ship or Queeg has to go. The executive officer, Lt. Maryk, spurred on by the ship's intellectual, and other crew members, takes over the ship until the emergency is over. By dint of a sharp lawyer and jargon-happy psychiatrists, the crew is not punished, while Queeg is censured. However, the moral of the novel can be summed up in the words of Willie Keith, the author's protagonist,

"I see that we were in the wrong. The idea is, once you get an incompetent ass of a skipper—and it's a chance of war—there's nothing to do but serve him as though he were the wisest and best, cover his mistakes, keep the ship going, and bear up. So I have gone all the way around Robin Hood's barn to arrive at the old platitudes, which I guess is the process of growing up."

It is true that these snatches of literature have, as the central problem, the Individual and the Society. But history translates Society in different forms and shapes. *Antigone* was bucking up against Society, but here Society meant a rigid *code of custom and folklore*—a stone wall of rites. *Billy Budd* bucked society too. But Melville cloaked the pathetic Budd into the *moral* issues of the

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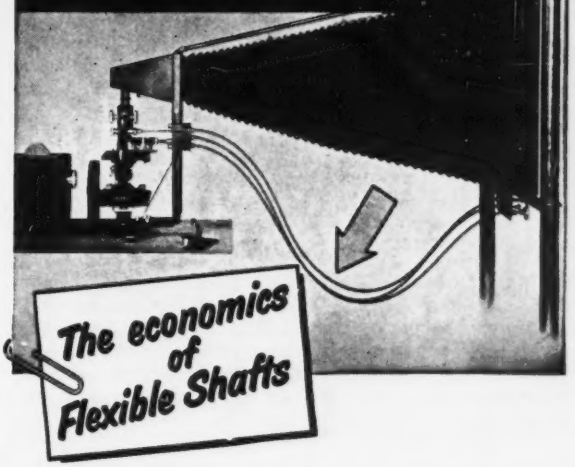

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time, and he twitted us by having Evil win. *The Caine Mutiny* analyzes the modern problem, that of the individual against the organization. In these pages the modern tragedy bares itself. In the former two cases, the individual loses, but we hate it. In *The Caine Mutiny*, the individual wins, but we hate it. Even Barney Greenwald, the sharp lawyer who walks away with the case, flings his drink in the face of one of the chief mutineers, disgusted at the thought of beating authority.

We are raising, says William Whyte, managing editor of *Fortune*, "a generation of social technicians, not rebels." The remainder of this essay will discuss this trend toward subservience to the organization, toward the "jury of our peers," and toward conformity.

CONFORMITY AND THE "OTHER DIRECTED MAN"

The specter of conformity can be easily illustrated by observing our changing concept of success. Reading Frederic Lewis Allen's *The Big Change*, one is convinced that our late 19th and early 20th century industrial leaders were in fact Horatio Algers. Spawned from meager, humble backgrounds, with little or no formal education, these men climbed a jagged path to success. The Captains of Industry were men who could drive a hard bargain, lonely men, moral men, men who stood vast unpopularity, men who would not blink at crushing of strikes with armed guards.

Today our management executive and to some extent our labor leaders are college trained men. They are trained in the important art, not of production, but of persuasion. If promising, they have had technical courses on everything from "leadership" to "psychotherapy." The pathway to the top is marred only by several obstacles—all titled "how to get along with people." They are polished, polite, and can serve up a mean martini.

David Riesman, in his stimulating book *The Lonely Crowd* talks about this present day man in terms of a radar set. The "Other-Directed Man" rests his conformity on sensitive attention to the expectations of his contemporaries. He obeys a fluctuation series of short run goals picked up by his internalized radar. These goals are set by careful surveillance of his peers. He is dominated by the *group* and shares his preoccupations with their reactions to him and his to them. Space limitations do not permit me to develop the genesis of this other directed man. It is both cause and consequence of sweeping and accelerated changes in our social structure wrought by the industrial revolution, separation of management from ownership, movement from city to the suburb, weakening of parental control, etc. Erich Fromm, the psychoanalyst, coined the phrase "Marketing" orientation to describe the same character type. Here the person isn't interested in life and happiness, but saleability. And this saleability quotient must be found not in reference to himself, but in the opinions of the others around him. Thus the model of other-directed man is an onion—a nihilistic one—which like a well trained burlesque dancer can take off the correct number of layers to please the crowd. Before mixing any more metaphors, it should be said that since the other-directed man cannot find his identity in reference to himself, he

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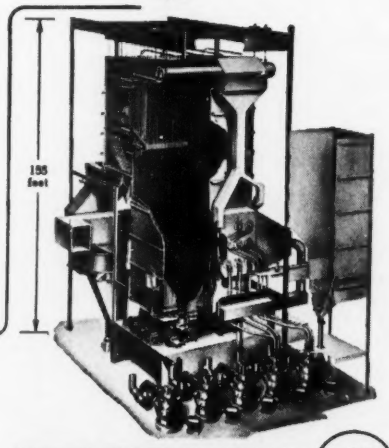

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must find the conviction of his identity in th opinions of others about him.*

PRESENT DAY PATHOLOGY

The furor over the current "Court of Inquiry" of Colonel Schwable raises some interesting problems for our society. The distinguished Marine court was particularly bothered at the fact that Colonel Schwable did not experience any physical hardship and yet "confessed." His defense pointed out that he had experienced far worse, more cunning pressures than the traditional tortures. What were these cunning and subtle pressures which brought about the brave colonel's capitulation? Isolation from fellow Americans. Even the exchange of notes in the latrine, common practice, was prohibited to him. As Douglas Cater writing in the Reporter put it, "Losing a sense of the community, he lost touch with reality . . . Was it a weakness of the individual or of a service whose men are imbued with an extraordinary esprit de corps?" We can assume that Col. Schwable was guilty of having been "brainwashed"; i.e. deprived of normal contact with other human beings. Any student could be likewise "brainwashed" by a simple recipe: (1) Arrange for all students, save one, to meet with the instructor before the first class. (2) Devise a scheme where "naive student" answers perfectly obvious questions the correct way. (3) Have entire class disagree, then jeer at now "wrong" student. (4) Repeat episode two to four times depending upon student. (5) Cook slowly; at end of two classes should have well baked anxiety neurosis. Later in the paper I will discuss a laboratory experiment which uses this recipe.

This need *to belong*, to be *consensually validated* has made it miserable for the "odd-balls" and other assorted lonely ones. Erich Fromm reports the following experiment with various classes of undergraduate students. They were told to imagine that they were to stay alone in their rooms for 3 days, without a radio, escapist literature, although provided with "good" literature, food and all physical comforts. Their reactions to this hypothetical experience varied from acute panic to that of an extremely harrowing experience. Only a very small percentage (about 10%) felt they would be at ease and enjoy the time when they are by themselves.

The quest for the modern holy grail, "to be well-liked," has penetrated the academic environs also. Professor Herbert Shepard of M.I.T. is currently studying the organization of physical scientists. When asked to complete the sentence, "Yeah, but he'll never get along around here until he . . .", over 45% of his sample physical scientists mentioned some human relations gambit or technique. And with the advent of more student evaluation of teaching faculty, we can expect the academician to borrow more from the role of the entertainer than from academic heritage.

FROM THE LABORATORY

Dr. Asch was interested in studying conditions that would induce individuals to resist or yield to group pressures, when this pressure is contrary to fact. He devised a simple and devastating experiment. A group of 8 individuals was instructed to judge a series of simple perceptual relations to match the length of a given line with one of three unequal lines. One of the 3 lines was clearly the same length of the given line. Each member of the group is supposed to announce his answer publicly. Of the group in question, 7 of the 8 members had previously met with the experimenter and received instructions to respond at certain points with the wrong answer. There were 18 trials, 6 of them "neutral;" i.e. the stooges unanimously answered incorrectly on 12 trials. Put yourself, if you don't fear grim experiences, in the position of the "naive" subject. Imagine 7 people, 7 sane looking people, all before you contradicting the evidence of your senses. Of the 50 college students that undertook the experiment, about 33% of all subjects changed their estimates toward the direction of the majority, the rest stood firm. When Asch placed a partner in the 4th position, that is, one who responded with the correct answer, the pressure of the group dwindled considerably.

If we could switch the experimental laboratory to northern Korea, and imagine, not college students, but prisoners of war, would it be feasible to imagine that one-third of the American prisoners might really believe that they had dropped germ bombs? Even if they were in the Infantry?

Dr. Mills at the Harvard Social Relations Laboratory has conducted research on an equally ingenious experiment. This is a three man situation

*In extreme form, the popular joke is told of two psychoanalysts meeting on the street. First psychoanalyst to second: "You're fine, how am I?"

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BALL AND ROLLER BEARINGS

with two of the men working as stooges.* Mills made up a synopsis of the Billy Budd story and asked his three men to read it and vote on a slip of paper whether or not they thought Budd should be hanged. When this was done, they were asked to come to a unanimous agreement if possible on the decision. Now number 1 stooge moves into action. He ferrets out the "naive subject's" opinion and commences to support it and agree to it. Meanwhile stooge number 2 is observing through the one-way mirror-window. Then he comes back in the room and disagrees with stooge number 1 and the subject. Slowly and imperceptibly stooge number 1 moves toward agreement with stooge number 2. Finally the subject is left alone and holding the bag. Mills was particularly interested in the effect of a subject's attitude and decision when he has support and suddenly the support deserts him. In the preliminary findings it was found that in the majority of cases the naive subject switched his decision to the will of the two stooges. Indeed, many times the naive subject switched his decision the minute number 2 stooge took a vigorous stand against his point of view.

ANOMIE OR WHO'S GOT THE INDIVIDUAL NOW

Emile Durkheim is known as one of the founders of modern sociology. One of his core concepts was "anomie," a word not directly translatable from the French, but defined as the state of mind of an individual who is separated from belonging to any stable group. Thus anomie means loneliness and disintegration of the individual brought about by having no stable attachments or roots. Durkheim believed that this state of anomie was sparked by the industrial revolution and its concomitant havoc which splintered families, shattered the chains of feudal life and close village ties, and isolated the family in a new, rushing, lonely cage-like city.

Every socially conscious social scientist and humanitarian has in their own peculiar ways sought the second coming of a rural community—to fight this anomie. This ressurection has many different forms. Some psychoanalysts for example believe that this salvation can come only through individual *productivity*. That the individual has got to feel productive as our ancestors did. A friend of mine, taking this as gospel, found a job in a harpsichord factory, one of the few factory operations where the worker stays with the product throughout its entire process.

Robert Tannenbaum and others believe that the Union is the institution that is needed to save the individual from anomie. In a closely reasoned and erudite work, he claims that it is inevitable for the individual to feel closest to work and the plant. He concludes that the Union offers the kind of cohesive unit which the worker needs.

Elton Mayo, founder of the comparatively new field of Industrial Sociology, agreed with Tannenbaum about the importance of work and about everything else, except that he didn't exactly have the Union in mind for his anomie-detergent. He believed that the plant or factory should be the milieu of "spontaneous cooperation." Testifying to Mayo's thesis, a recent series of articles in *Fortune* magazine called "The Transients" points out that the modern corporation creates so many moves that the corporation man is unable to develop roots in any stable social structure. Hence he has roots in only one direction: the corporation.

Religion, Family, TV, Sports all make bids for this restless destiny of modern man to settle down and devote his emotional commitment to their organization. So far, he hasn't made a choice.

EPILOGUE

Part of the American Dilemma turns on our lip service to shibboleths which contradict each other. Thus, we're all for the rugged individualism and "going it alone," and at the same time are "best damned team players" you ever saw. Incidentally, this doesn't go unnoticed in our foreign policy. There are few of us who didn't identify ourselves with Gary Cooper in "High Noon" or Montgomery Clift as Prew in "From Here to Eternity." To reconcile our need for "belonging," with the longing for independence and autonomy remains the question of the century: the struggle of the Individual and the Organization.

*The use of stooges in social science experiments caused the present President of the American Sociological Society to remark at the annual meeting that there should be a text book on "Care and Feeding of the Stooge."

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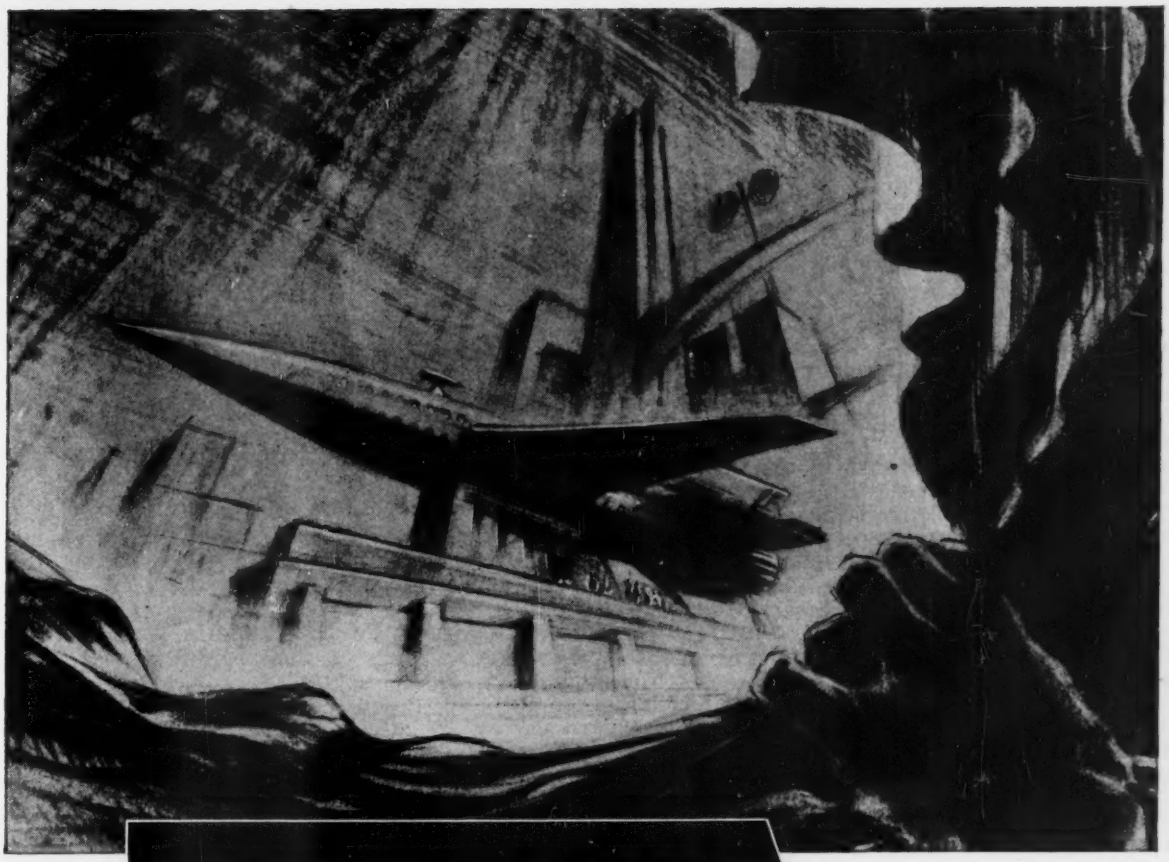

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alkylation

by Tom Cantrell '55

Gulf Oil alkylation plant, Port Arthur, Texas.

High octane gasoline has become one of the modern necessities of life since the advent of the hot V-8 engines of the Olds 88 philosophy of design. Highly branched hydrocarbons have been found to have the best anti-knock properties, while straight chain hydrocarbons have the poorest. To measure the relative anti-knock properties of different fuels, two standard compounds were chosen. Normal heptane is a straight chain molecule and has poor anti-knock properties. Isoöctane is branched, and thus has excellent anti-knock quality. The fuel whose performance is being measured is compared with blends of these two standard compounds. The per cent isoöctane in the blend that matches it in knocking properties is then the octane number of the fuel.

So much for the meaning of high octane. Now we shall consider a process which is widely used for making the highly branched hydrocarbons for blending into premium and aviation gasolines.

An olefin, or unsaturated hydrocarbon, can be reacted with a paraffin, or saturated hydrocarbon to yield a saturated hydrocarbon with a molecular weight equal to the sum of the weights of the starting compounds. In less profound terms two little molecules unite to form one big one.

Gasoline is made up mainly of molecules containing six, seven, or eight carbons. To make a gasoline molecule by the above process, we should start with molecules with three or four carbons. The development of catalytic cracking provided a large source of C_4 compounds. Since we are trying to make high octane gasoline, the C_4 compounds should be chosen so as to combine to give a branched-chain molecule. The compounds to use, therefore, are isobutane, a branched four carbon paraffin, and butene, a four carbon olefin.

Unfortunately, the isobutane and butene cannot be dumped into a drum and stirred to get gasoline. The reaction can be made to go, however, under conditions of high temperature and pressure, or under milder conditions with a catalyst.

The first process is called thermal alkylation. The reaction is carried on at 3000-5000 pounds per square inch, and at temperatures of 900-1000°F. The concentration of the olefin is always kept low —about five to ten percent of the mixture, by weight.

Use of the solid halide catalysts like boron fluoride or aluminum chloride reduces the pressure needed to about 1000 pounds per square inch and the temperature to about 450-500°F. Thus, despite the use of a catalyst, the alkylation is still a high temperature, high pressure operation.

When sulfuric acid is employed as the catalyst, the operation is run at 30-70°F. and under a pressure of about 100 pounds per square inch. Acid which is ninety five per cent H_2SO_4 is used. The catalyst and reactants are kept well agitated. After the materials pass out of the reactor, the acid and hydrocarbon phases separate.

The hydrogen fluoride process, which we shall examine in a little more detail, is similar to the sulfuric acid process, but presents several problems.

The feed stock mixture of butene and isobutane must be dry and sulfur free. Any water that is present is absorbed by the HF and weakens the acid. If the concentration of water in the acid is allowed to rise, the acid becomes corrosive. If sulfur is present in the feed stock, acid-soluble oil is formed instead of the desired branched octane. If this builds up to a high concentration, it will show up eventually in the end product. Sulfur is removed by treatment with caustic.

The clean feed stock is, on the average, in contact with the hydrofluoric acid for about fifteen minutes, although the time may vary from three minutes to forty. It is then passed into a settling drum where the hydrofluoric acid settles into the lower phase, and the hydrocarbons are drawn off the top.

The hydrocarbon phase is pumped to the acid stripper, where most of the HF and some light hydrocarbons are boiled off and collected. The recovered HF is returned to the contactor. The propane is stripped out of the collected hydrocarbons, and the remainder is refluxed into the acid stripper.

The stream from the bottom of the acid stripper tower is now virtually acid free hydrocarbon. It passes into the deisobutanizer tower where the unreacted isobutane is flashed off, collected, and recycled to the contactor.

The bottoms from the deisobutanizer tower are run through a bed of bauxite in a tower to eliminate the last traces of HF. The stream is next passed into the debutanizer where butane is removed overhead.

The remaining stream is then fractionated into a light alkylate stock suitable for blending into aviation gasoline and a heavy alkylate stock suitable for automotive fuel.

This process is one of the most important sources of high octane stock, and was instrumental in providing adequate supplies of aviation gasoline during the second World War.

A new Hercules plant under construction at Burlington, New Jersey, will make the essential raw material for Canadian production of 'Terylene'—polyester yarn. Known as dimethyl terephthalate, or DMT, this basic chemical for polyester fibers will be made by an entirely new process, and will be available eventually for plastics and other uses.

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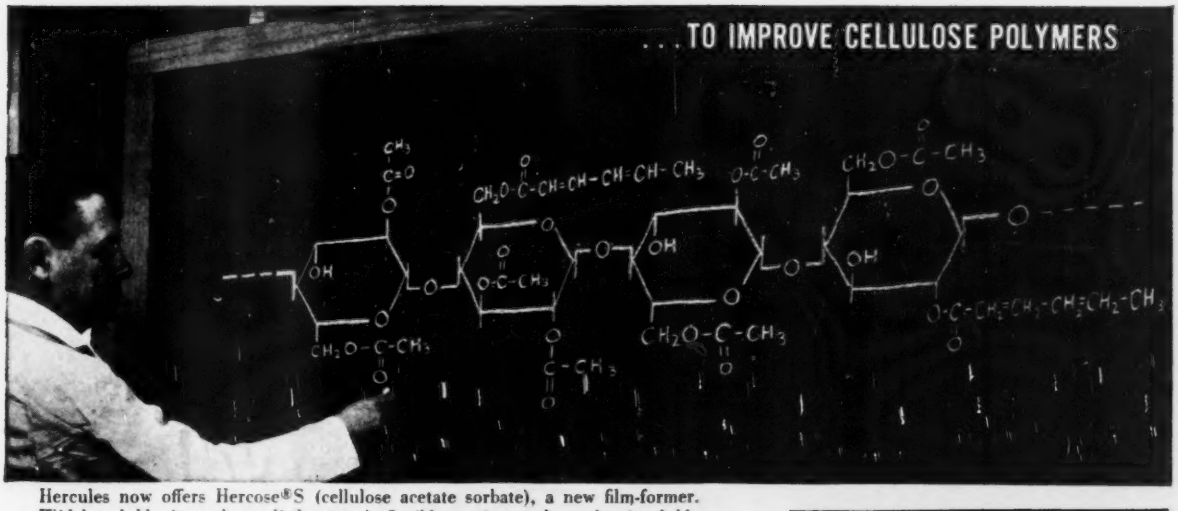

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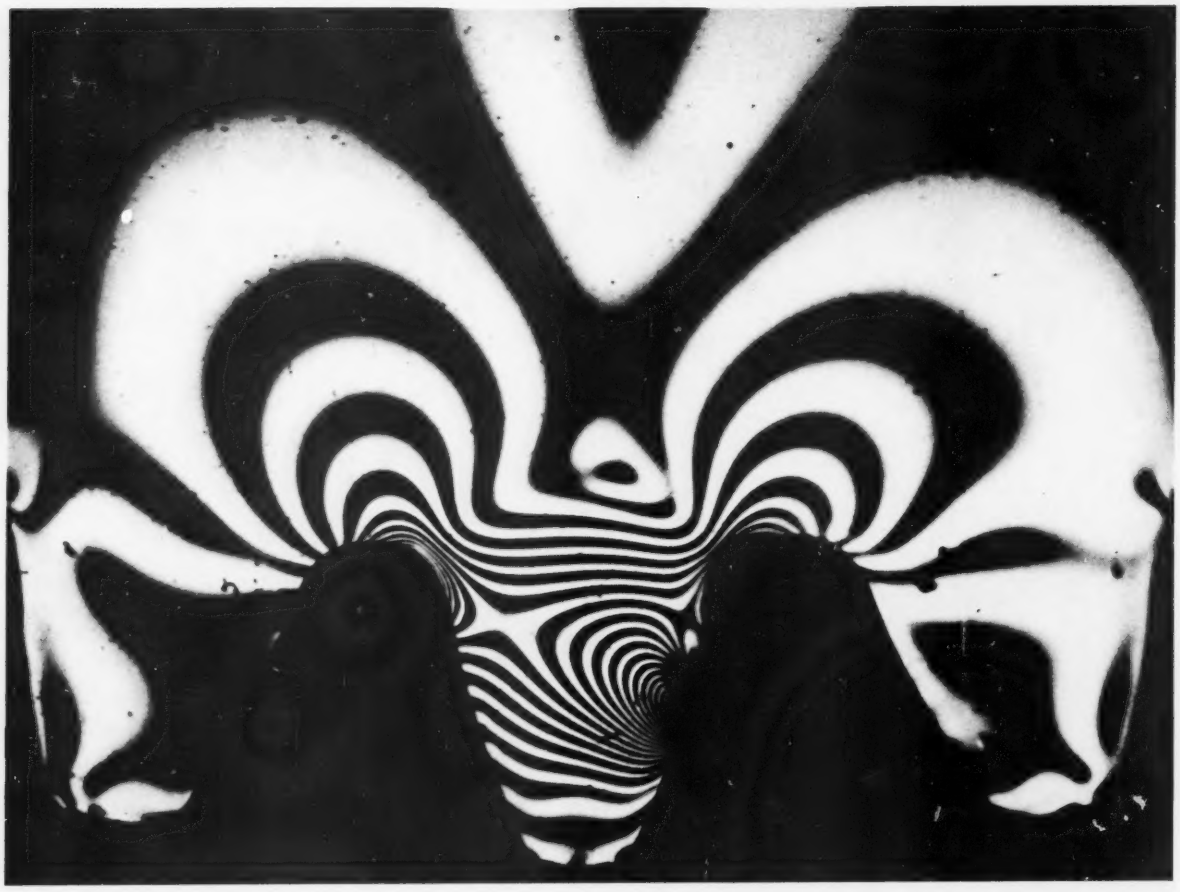

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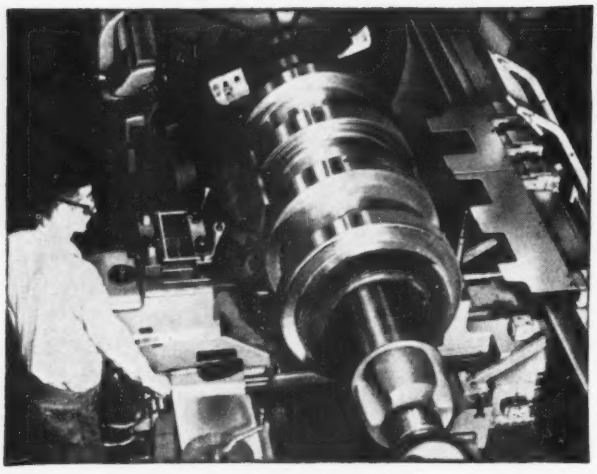
Another page for **YOUR BEARING NOTEBOOK**

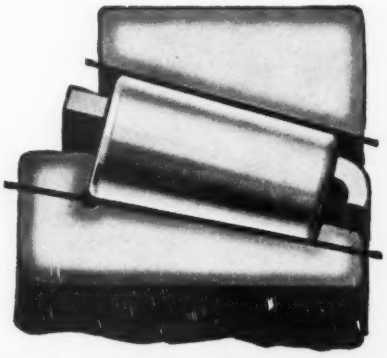


How to hold a heavily-loaded lathe spindle in accurate alignment

This big lathe machines rolls for steel mills. The roll is rotated by the lathe spindle and it must be machined to very accurate dimensions. So the lathe manufacturer, LeBlond Machine Tool Company, mounts the spindle on Timken® tapered roller bearings. Despite the great weight on the spindle, the Timken bearings hold it precisely in place—because they are made so accurately and have such high load capacity.

Why TIMKEN® bearings have high load capacity

This picture shows why Timken bearings have such high capacity—the load is carried on a *full line contact* between the rollers and races in the bearing. Note also the tapered construction. This permits the bearing to be tightened up (preloaded, we call it) to prevent chatter in rotating parts like the machine tool spindle above.



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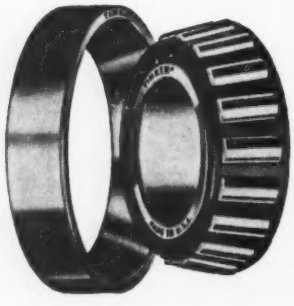

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Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬯ AND THRUST ⊣⬯⊢ LOADS OR ANY COMBINATION ✳

PHOTOGRAPHY AT WORK—No. 7 in a Kodak Series

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If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

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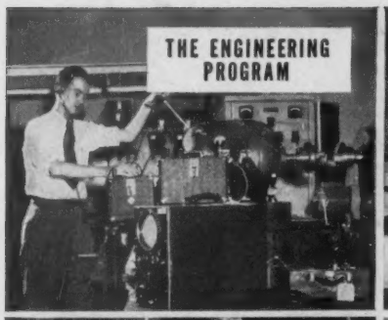
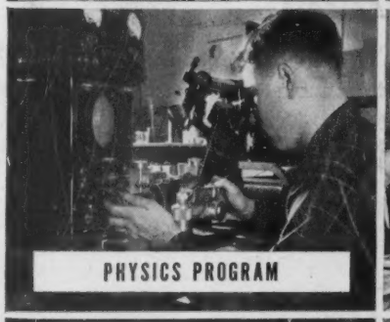
10 ways to build a successful career





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